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7 March 1946

[redacted]

From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.

Subject: Target Report - Japanese Torpedoes and Tubes, Article 2 - Aircraft Torpedoes.

Reference: (a)"Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, dealing with Target 0-01 of Fascicle 0-1 of reference (a), is submitted herewith.

2. The investigation of the target and the target report were accomplished by Lieut. R. R. Morin, USNR, with the assistance of Lieut. H. DeLacy, RNVR, with the advice of Comdr. C. F. Edwards, RNVR.

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Captain, USN

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O-01-2

JAPANESE TORPEDOES AND TUBES
ARTICLE 2
AIRCRAFT TORPEDOES

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945

FASCICLE O-1, TARGET O-01

MARCH 1946

U.S. NAVAL TECHNICAL MISSION TO JAPAN

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SUMMARY

ORDNANCE TARGETS

JAPANESE TORPEDOES AND TUBES
ARTICLE 2 - AIRCRAFT TORPEDOES

All research on aircraft torpedoes was conducted at the First Naval Technical Arsenal, KANAZAWA, Japan. The main plant concerned with production was the Kure Naval Arsenal.

There were no remarkable features about the aircraft torpadoes in operational use during the war, with the exception of the anti-roll stabilizers. The Japanese considered this innovation of great importance in improving torpedo performance.

Wooden tail frames, similar to those used on U.S. aircraft torpedoes, were used for air stabilization.

The launching speeds and altitudes varied from 100 to 250 knots and from 50 to 1000 feet.

Type 91, Modifications 1 to 7, carrying explosive charges of 330 to 925 pounds, were used throughout the war, but an improved Type 4 aircraft torpedo was introduced in 1944. All torpedoes had a speed of 42 knots with ranges of 1600 to 2200 yards.

The Japanese experimented with rocket and jet-propelled torpedoes, but without success. Many experiments were made with gliding torpedo bombs and with anti-submarine circling torpedoes with a moderate degree of success, but none was used in service.

In 1934 the Type 94 oxygen aircraft torpedo was developed, but the use of oxygen was troublesome and dangerous, and there was no need for long range, so it was abondoned soon afterwards.

The Japanese considered their aircraft torpedoes very dependable. The chief difficulty was in mass production, which was never really attained.

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LIST OF ENCLOSURES

LIST OF ILLUSTRATIONS

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REFERENCES

Location of Target:

First Naval Technical Arsenal, KANAZAWA, Japan.

Japanese Personnel Who Assisted in Gathering Documents:

Technical Comdr. K. FUKUBA, Aerial Torpedo Section, First Naval Technical Arsenal.

Japanese Personnel Interviewed:

Technical Rear Admiral S. NARUSE, in charge of the Aerial Torpedo Section, First Naval Technical Arsenal. (Active in torpedo design and development since 1919; studied Whitehead Torpedoes in England, 1927-28.

Technical Rear Admiral S. OYAGI, Technical Research Bureau, TOKYO. (Actively engaged in torpedo research and development since 1919; studied torpedoes in England, 1927-28.)

Technical Commander K. FUKUBA, chief torpedo designer at the First Naval Technical Arsenal. (Twelve years experience in torpedo design.)

INTRODUCTION

Information for this report was obtained in a series of interviews with responsible personnel connected with the development of aircraft torpedoes. The report presents as much data as could be obtained about aircraft torpedoes which were in operational use, and those in the experimental stages. The report as a whole endeavors to show the path along which Japanese aircraft torpedo development was progressing. It is to be noted that this report covers only aircraft torpedoes, information on other types being contained in NavTechJap Report, "Japanese Torpedoes and Tubes, Article 1, Ship and Kaiten Torpedoes", Index No. O-01-1.

THE REPORT

Part I

GENERAL INFORMATION ON JAPANESE AIRCRAFT TORPEDOES

The First Naval Technical Arsenal near YOKOSUKA, Japan was the only research establishment concerned with aircraft torpedoes. Specifications for new designs (speed, range, weight of explosive, etc.) were supplied by the Naval Ministry, Aircraft Technical Division in TOKYO. Kure Naval Arsenal was the main plant concerned with production, but lesser plants manufacturing different components of the torpedo were located all over Japan. Enclosure (A) lists the production and cost figures for all aircraft torpedoes from 1931 to 1945.

The sea acceptance tests were made on the SHARU SHIMA range just off YOKOSUKA. All the torpedoes were fired from a rack, which was lowered into the water, and run down the range under small barges which were anchored at intervals. No hydrophones were used on the range. The speed was measured by timing the first bubbles to appear on the surface at the starting point and at each test barge along the range. The recorder in the exercise head also registered the torpedo's speed as the difference between the velocity head and the static head. Depth was measured by recorder only. No nets were used on the range. All exercise heads and recorders are discussed in detail in NavTechJap Report, "Japanese Torpedoes and Tubes, Article 1 - Ship and Kaiten Torpedoes", Index No. 0-01-1.

Japanese aircraft torpedoes were not designed to meet requirements of specific airplanes but instead, the aircraft were modified to suit the torpedo.

The maximum and minimum altitudes for dropping torpedoes were approximately 1000 feet and 50 feet. All the latest type torpedoes were designed for a water-entry speed of 400 knots. Depth of dive was never specified, but in practice, shallow water shooting in a depth of 40 feet was satisfactory. For shallow initial dives an altitude of 100 feet, with an air speed or 140 knots, was used most often. The wooden tail frames used for air stabilization are described in Part II of this report. The maximum conditions under which a torpedo could be launched without structural failure, were 1000 feet at 250 knots, but the Japanese considered 330 feet and 180 knots as the best combination for a desired entry angle of 17-20°.

To prevent damage to the warhead on impact with the water, a rubber sheath, approximately 0.4 inches thick, was used to cover about 24 inches of the nose of the torpedo. This cover would shatter into small fragments when it hit the water.

A length to diameter ratio of 11 or 12 was found by the Japanese to be most satisfactory. They considered the U.S. aircraft torpedoes too short for a good underwater trajectory.

Rear Admiral NARUSE stated that many U.S. Mark 13 type torpedoes were sent to the First Naval Technical Arsenal for study. Some of them were equipped with shroud rings but he did not know where, or under what circumstances they were recovered. He claimed to have tried the shroud ring on Japanese aircraft torpedoes about ten years ago, but didn't like it because of the increased resistance, and interference with the propellers.

Model experiments were carried out at the First Naval Technical Arsenal in a large water tunnel, and with a catapult and water tank. These are discussed

in NavTechJap Report, "Japanese Ordnance Research, Article 3 - Torpedo Models", Index No. 0-39-3.

Eight tail fins were tried on some of the Type 91 torpedoes, but experiments showed that recovery from the initial dive was too slow. The eight-fin torpedo exhibited steadier water travel characteristics than the four-fin torpedo, but it took 800 yards to reach a steady depth level. The four-fin torpedo took only 380 yards to assume its proper depth level. As a result of the experiments, eight fins were abandoned for aircraft torpedoes.

The Japanese considered the small anti-roll flippers on each side of the torpedo as one of the most important features. The use of these roll stabilizers enabled them to carry a full charge of explosive in the warhead, and they also were responsible for eliminating the hook when the torpedo entered the water. The anti-roll stabilizers are discussed more completely in Part II of this report.

In 1941 some experiments were made with a jet-propelled torpedo, and in 1944 with a rocket torpedo. From 1943 to the end of the war the Japanese experimented with "KURAI" gliding torpedo bombs. All these experimental torpedoes are covered in detail in Part III of this report.

In 1944 experiments were made in an effort to develop an airdraft torpedo using hydrogen peroxide with hydrazine hydrate and kerosene. They were discontinued after a few months because of difficulties encountered in the handling of hydrogen peroxide.

Two-stage reducers were used in all the Type 91 torpedoes because they produced a very stable reduced air pressure. They were complicated and difficult to manufacture, so a one-stage reducer was used in the Type 4 torpedo. This was considered satisfactory and much simpler to produce than the two-stage type.

The great shortage of copper in Japan necessitated the replacement of all possible bronze parts with steel. This resulted in much difficulty with overhaul and preservation of torpedoes, which were stored for long periods of time.

From the end of 1944 until April 1945, about 200 Type 4 torpedoes were produced. They were practically the same as the Type 91 torpedoes, but were stronger and simplified in design for ease in production and handling. No information was obtained on service results.

The weak points of the torpedo at water entry are in the warhead joint, and in the shell of the engine room and buoyancy chamber. When the entrance angle is too low due to high speed and low altitude, the torpedo skips and buckles in the vicinity of the buoyancy chamber.

Many experiments were made with net cutters on the nose of torpedoes, but were unsuccessful because of rudder disturbance caused by excessive cavitation from the net cutters.

No figure-run devices were used on aircraft torpedoes.

Only the main parts of the torpedo, such as the air vessel, afterbody, and tail section were interchangeable. The warheads were not interchangeable with different modifications of aircraft torpedoes. The heaviest types were used in land-based torpedo planes and the lightest ones in carrier-based aircraft.

Cold weather experiments were conducted in Hokkaido and northern Korea. The main problem was lubricating oil, but a special oil developed at the First Naval Fuel Depot at OFUNA, performed satisfactorily. The tests consisted of taking the torpedo up to an altitude of 13,000 feet then descending quickly

and launching the torpedo.

Hot weather experiments were made in the vicinity of Singapore. Rust and storage problems were investigated. It was found that without a thick coating of grease, rust formed within two hours after the torpedo was exposed to the tropical atmosphere. Painted warheads were left exposed in the sun and atmosphere for a period of one year and were still in satisfactory condition after that time.

Rear Admiral NARUSE stated that seven Type 91, Modifications 1 and 2, torpedoes sank HMS PRINCE OF WALES, and seventeen of the same type and modifications sank HMS REPULSE. This was the only information obtainable on service results of Japanese aircraft torpedoes.

EXPLANATION OF JAPANESE SYSTEM FOR CLASSIFYING AIRCRAFT TORPEDOES

The term TYPE is used to designate a particular design of torpedo and corresponds to the American and British term "MARK". The type number refers to the year in which the design was started. Thus, Type 91 refers to the Japanese year 2591 or 1931 A.D.

The term MODIFICATION is added whenever the size of warhead is changed. Some minor details of the torpedo may also be modified, but the main differences between Type 91, Modifications 1, 2, and 3, are in warhead sizes. The type and modification numbers apply to the whole torpedo including the warhead.

When Type 91, Modification 3, was strengthened to allow a higher launching speed, the term IMPROVED was added.

Still further strengthening caused the term STRONG to be added in place of IMPROVED. The aircraft torpedo was then designated as the Type 91, Modification 3, STRONG. The only differences between Type 91, Modifications 3, 4, and 7 (strong) are in the size of warhead used.

In 1944 (Japanese year 2604) the Type 91 aircraft torpedo was greatly strengthened and also simplified in construction, for ease of manufacture and production. (The degree of simplification is discussed later.) It was then designated as the Type 4 aircraft torpedo.

The term MODEL is sometimes used in connection with aircraft torpedoes, and refers only to the method of propulsion.

- Model 1 - Ordinary type of aircraft torpedo
- Models 2-3 - Jet-propelled torpedoes
- Models 4-8 - Bomb-torpedoes with no propulsion

Both the terms MARK and TYPE are used in designating warheads. Therefore, it is important to note that warheads Mark 4 and Type 4 are distinctly different.

The Japanese admit their system of classifying torpedoes and torpedo components is confusing, even to themselves. For example, the Type 4 aircraft torpedo is sometimes designated as the Type 4, Model 1, Mark 2 torpedo. It is really only a Type 4 torpedo with a Mark 2 warhead.

Part II

JAPANESE AIRCRAFT TORPEDOES IN OPERATIONAL USE DURING WORLD WAR II

A. Principal Differences in Japanese Aircraft Torpedoes

The following is a list of all the types and modifications of aircraft torpedoes which were in operational use, with the year they appeared and the principal changes made over the preceding type. A complete list of particulars is

given in Tables I through XI.

1. Type 91 Modification 2 (1941)

   Explosive charge increased from 330 to 450 lbs.
   Thickness of air vessel reduced from 7.0mm to 6.1mm.
   Anti-roll stabilizers first adopted.

2. Type 91 Modification 3 (1942)

   Explosive charge increased to 528 lbs.
   Thickness of air vessel increased to 2mm.
   Air vessel charging pressure increased to 180 kg/cm^2 (2560 psi).
   Eight tail fins tried on some.
   Bronze parts replaced with steel where possible.
   Pendulum weight increased from 11.6 to 13.9 lbs.

3. Type 91 Modification 3 (Improved) (1943)

   Top side afterbody and engine room strengthened with longitudinal T-shaped bars.
   Maximum launching speed increased to 300 knots.

4. Type 91 Modification 3 (Strong) (1944)

   Top side of afterbody strengthened with I - shaped bars instead of T - shaped bars.
   Underside of warhead nose strengthened with I - shaped bars.
   Maximum launching speed increased to 350 knots.
   Thickness of air vessel decreased from 7.0mm to 6.1mm.
   Air vessel charging pressure decreased to 160 kg/cm^2 (2280 psi).
   Range decreased to 1500 meters (1640 yards).

5. Type 91 Modification 4 (Strong) (1944)

   Explosive charge increased to 675 lbs.

6. Type 91 Modification 7 (Strong) (1944)

   Explosive charge increased to 920 lbs.

7. Type 4 (April 1945)

   Further strengthening.
   Maximum launching speed increased to 400 knots.
   Weight of pendulum increased from 13.0 to 16.5 lbs.
   Effective area of diaphragm increased.
   Servomotor for horizontal rudder mounted under depth gear for ease in removing.
   One-stage reducer instead of two-stage.
   Improved type of free-wheeling for propellers.
   Oil distributor removed. Direct pipe leads with nozzles used instead.
   Horizontal rudders strengthened.
   Same type gyro used for steering and anti-roll stabilizers.
   All possible parts simplified in design for maximum production.
   All phosphor-bronze parts changed to steel wherever possible.

B. Air Vessel

The air vessel is a forged steel cylinder with the after bulkhead formed as part of the original forging. The forward bulkhead is removable and held in place by eight bolts. A fish paper gasket is used in the joint, and high

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Table I
JAPANESE AIRCRAFT TORPEDOES
Description and Performance Data

		Type 91							Type 4	Type 4
		Modif. 1	Modif. 2	Modif. 3	Modif. 3 (improved)	Modif. 3 (strong)	Modif. 4 (strong)	Modif. 7 (strong)	Warhead Mark 2	Warhead Mark 4
Wt. of explosive charge	lbs.	330	450	530	530	530	680	925	670	920
Total weight of warhead	lbs.	473	610	725	725	725	860	1150	920	1190
Length of war-head	inches	37.8	45.6	57.5	57.5	57.5	57.5	74.8	57.5	74.8
Total length	inches	207.7	216.0	207.7	207.7	207.7	207.7	225.0	207.7	225.0
Diameter	inches	17.71	17.71	17.71	17.71	17.71	17.71	17.71	17.71	17.71
Total weight	lbs.	1728	1840	1872	1890	1890	2030	2320	2170	2435
Displacement	lbs.	1500	1568	1492	1492	1492	1492	1656	1480	1636
Negative buoyancy	lbs.	228	272	380	398	398	538	664	690	799
C.G. from tail end	inches	118.2	122.8	118.5	120.0	120.0	121.2	134.4	121.2	131.5
C.B. from tail end	inches	118.0	122.0	118.2	118.2	118.2	118.2	126.8	117.7	126.2
Trim	inches	-0.2	-0.8	-0.3	-1.8	-1.8	-3.0	-8.1	-3.5	-5.3
Specific weight		1.15	1.17	1.25	1.26	1.26	1.36	1.40	1.46	1.49
Pull around	lbs.	79.4	81.5	99.0	63.0	61.5	7.5	8.35	20.2	20.2
Horsepower		140	140	140	140	140	140	140	140	140
Speed	knots	42	42	42	42	42	42	41	42	41
Range	yards	2200	2200	2200	2200	1640	1640	1640	1640	1640
Maximum launching velocity	knots	260	260	260	300	350	350	350	400	400

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Table II
JAPANESE AIRCRAFT TORPEDOES
Air Vessel

	Units	Type 91 Modif. 3 (improved)	Type 91 Modif. 3 (strong)	Type 4
Charged pressure	psi.	2560	2275	2275
Volume	cu. ft.	6.45	6.47	6.47
Wt. of air	lbs.	83.7	73.0	73.0
Wall thickness	inches	0.276	0.240	0.240
Length	inches	42.1	42.1	42.1

Table III
JAPANESE AIRCRAFT TORPEDOES
Liquid Capacities

	Units	Type 91 Modif. 3 (improved)	Type 91 Modif. 3 (strong)	Type 4
Vol. of water	pints	30	30	30
Vol. of fuel	pints	8.65	8.65	7.40
Vol. of oil	pints	6.75	6.75	6.32

Table IV
JAPANESE AIRCRAFT TORPEDOES
Reducer

	Units	Type 91 Modif. 3 (improved)	Type 91 Modif. 3 (strong)	Type 4
Type		2-stage	2-stage	1-stage
Pressure	psi	570	570	570

Table V
JAPANESE AIRCRAFT TORPEDOES
Engine

	Units	Modif. 3 (improved)	Modif. 3 (strong)	Type 4
Type		8-cyl. radial	8-cyl. radial	8-cyl. radial
Weight	lbs.	183	183	174
Cylinder bore	inches	3.54	3.54	3.54
Stroke	inches	3.34	3.34	3.34
Inlet pressure	psi.	570	570	570
Engine timing expansion ratio	%	37	37	37
Max. horse-power		210	210	210
RPM at max. hp		1260	1260	1260
Air efficiency	hp/lb/sec	550	550	550

Table VI
JAPANESE AIRCRAFT TORPEDOES
Combustion Chamber

	Units	Modif. 3 (improved)	Modif. 3 (strong)	Type 4
Volume	cu. ft.	0.05	0.05	0.049
Air to fuel ratio		10-12.5	10-12.5	10-12.5
No. of igniters	1	2	2	2
Air consumption	lbs/sec	0.485	0.485	0.485
Water to fuel ratio		3.5	3.5	3.5

[redacted]

Table VII
JAPANESE AIRCRAFT TORPEDOES
Shell Thickness

	Units	Modif. 3 (improved)	Modif. 3 (strong)	Type 4
Buoyancy chamber	milli-meters	top - 2 bottom - 3	3.0	3.0
Engineroom	milli-meters	top - 2 bottom - 3	3.0	3.0
Afterbody	milli-meters	top - 2 bottom - 3	front-3.5 rear-3.0	front-3.5 rear-3.0
Tail cone	milli-meters	2.5	2.5	2.5

Table VIII
JAPANESE AIRCRAFT TORPEDOES
Depth Gear

	Units	Modif. 3 (improved)	Modif. 3 (strong)	Type 4
Total wt.	lbs.	30.8	30.8	28.6
Wt. of pendulum	lbs	13.9	13.9	16.5
Eff. area of diaphragm	sq. inches	3.04	3.04	2.57
Depth setting	feet.	6.5-65	6.5-65	6.5-65

Table IX
JAPANESE AIRCRAFT TORPEDOES
Propellers

	Units	Modif. 3 (improved)	Modif. 3 (strong)	Type 4
No. of props.		2	2	2
No. of blades each prop.		4	4	4
Diam. of forw'd prop.	inches	15	15	15
Diam. of after prop.	inches	13.5	13.5	13.5

Table X
JAPANESE AIRCRAFT TORPEDOES
Passing Conditions

	Units	Modif. 3		Type 4
		(improved)	(strong)	
Speed	knots	42 ± 1	42 ± 1	42 ± 1
Range & over run	yards	2200 + 10%	1640 + 10%	1640 + 10%
Depth keeping	feet	± 1.5	± 1.5	± 1.5
Deflection	yards	± 1% of range	± 1% of range	± 1% of range

pressure air tightly seals the bulkhead against the air vessel flange. The forward bulkhead may be removed in a similar manner to bulkheads in U.S. torpedoes by rotating and withdrawing through two slots.

Air vessels on torpedoes prior to the Type 91, Modification 3 (Strong) were fitted with drain plugs, but the later models had none as only dry air was used. Silica-gel was used to remove the moisture from the air before charging.

A heavy mineral oil was originally used to preserve the internal ground surface of air vessels, but later a "liquid grease" was adopted. This "liquid grease" was developed at the First Naval Fuel Depot at OFUNA.

The main air pipe is made of standard A.R. copper and fits into the center of the after bulkhead with a knife-edge joint. No difficulties were experienced with air vessel leaks.

The thickness of air vessels varied from 6.1mm to 7mm (0.240 to 0.276 in), and the design safety factor from 1.89 to 1.93.

In order to strengthen further the torpedo and still maintain the same total weight, the thickness of the air vessel was decreased in the Type 91, Modification 3 (Strong).

Air vessels were manufactured at different factories, and three main types of steel were used consistently. The compositions of and specifications for the three types of steel are given in Tables XII and XIII.

Table XI
JAPANESE AIRCRAFT TORPEDOES

Torpedo	Warhead	Torpedo plus Warhead	Exploder	Exercise Head	Gyro
Type 91 Modif. 1	Type 91 Modif. 1	Type 91 Modif. 1	Type 90 Model 2	Type 91 Modif. 1	Type 91
Type 91 Modif. 2	Type 91 Modif. 2	Type 91 Modif. 2	Type 90 Model 2	Type 91 Modif. 2	Type 91
Type 91 Modif. 3	Type 91 Modif. 3	Type 91 Modif. 3	Type 90 Model 2	Type 91 Modif. 3	Type 91
Type 91 Modif. 3 (improved)	Type 91 Modif. 3	Type 91 Modif. 3 (improved)	Type 90 Model 2	Type 91 Modif. 3	Type 91 Modif. 1
Type 91 Modif. 3 (strong)	Type 91 Modif. 3 (strong)	Type 91 Modif. 3 (strong)	Type 90 Model 2 (strong)	Type 91 Modif. 3 (strong)	Type 91 (strong)
Type 91 Modif. 3 (strong)	Type 91 Modif. 4	Type 91 Modif. 4 (strong)	Type 90 Model 2 (strong)	Type 91 Modif. 4	Type 91 (strong)
Type 91 Modif. 3 (strong)	Type 91 Modif. 7	Type 91 Modif. 7 (strong)	Type 90 Model 2 (strong)	Type 91 Modif. 7	Type 91 (strong)
Type 91 Modif. 3 (strong)	Type 3 (kite)	Type 91 Modif. 3 (strong) with type 3 head	Type 90 Model 2 (strong)	Type 3	Type 91 (strong)
Type 91 Modif. 3 (strong)	Type 4 (V-head)	Type 91 Modif. 3 (strong) with type 4 head	Type 90 Model 2 (strong)	none	Type 91 (strong)
Type 4	Mark 2	Type 4 Mark 2	Type 4	Mark 2	Type 4
Type 4	Mark 4	Type 4 Mark 4	Type 4	Mark 4	Type 4
Type 4	Type 3 (kite)	Type 4 with type 3 head	Type 4	Type 3	Type 4
Type 4	Type 4 (V-head)	Type 4 with type 4 head	Type 4	none	Type 4

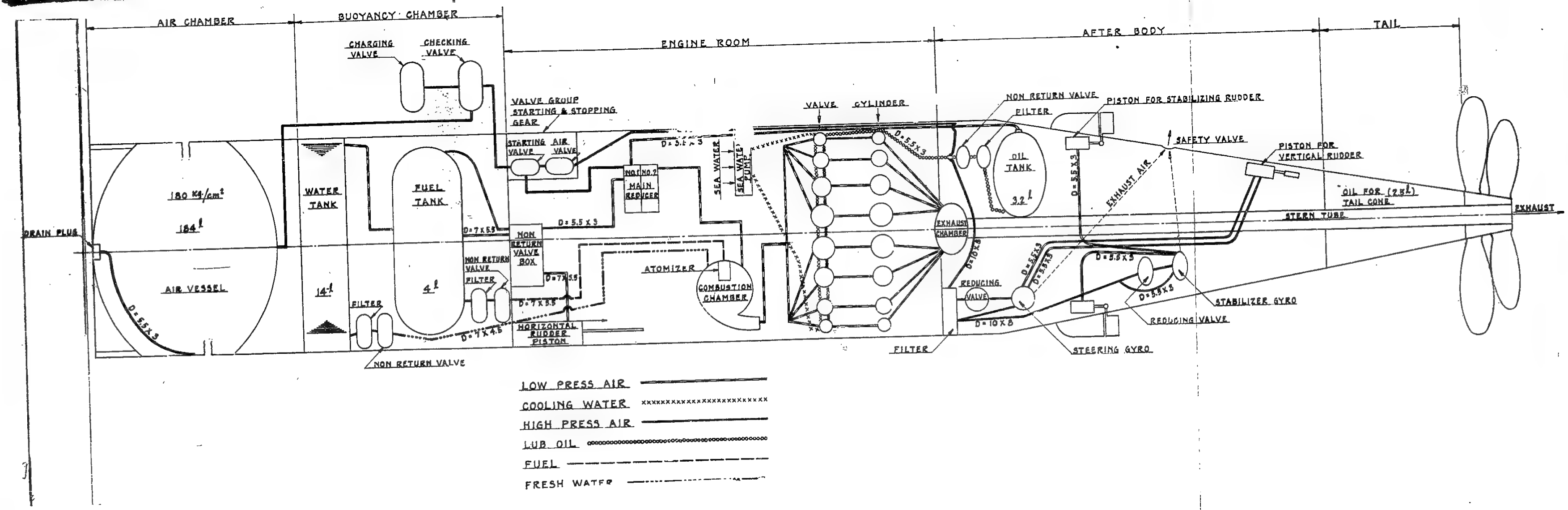

Figure 1

SCHEMATIC DIAGRAM FOR TYPE 91 MODIF. 3 TORPEDO

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Table XII
COMPOSITION (%) OF STEEL FOR AIR VESSELS

Steel Type No.	C	Si	Mn	Ni	Cr	Cu	Mo
V7	0.25	0.25	0.8	1.8	1.0	1.0	0.5
SK	0.35	1.0	1.0		1.2		0.4
V9	0.30	0.25	1.0	1.0	1.0	0.4	0.3

Table XIII
MINIMUM SPECIFICATIONS FOR STEEL FOR AIR VESSELS

Steel Type No.	Breaking Strength (psi)	Elastic Limit (psi)	Izod Shock Value (ft lbs)
V7	157,000	142,200	22
SK	157,000	142,200	22
V9	157,000	142,200	22

In hydraulic bursting tests, air vessels withstood approximately six times the normal working pressure before failing.

A bayonet joint ring secures the head to the air vessel, the midship section to the afterbody, and the after body to the tail. Geared racks, which have to be turned by special tools, rotate the rings to lock or unlock the bayonet joint. The midship section is screwed to the air vessel and sweated.

C. Midship Section

The midship section is divided into two sections, separated by a bulkhead. The forward part is a watertight buoyancy chamber, 29" long, and the after part allows admittance of sea water. The buoyancy chamber contains two water bottles, a fuel bottle, depth mechanism, a relief valve, and stop and charging valves. The after section contains a depth-keeping servomotor, controlling gear, starting valve, combined non-return valve, and also forms a housing for the engine when the afterbody is coupled to the midship section.

D. Afterbody

The afterbody contains a relief valve, a lubricating oil bottle, two disc reducers, gyroscope and steering engine for operating the vertical rudders, and gyroscope and two steering engines for operating the anti-roll rudders. Fitted on the forward bulkhead, but outside the buoyancy chamber, are the engine, main reducer and combustion chamber.

E. Tail

The tail is a conical steel forging fitted with vertical and horizontal fins and rudders. The tail body, which is a water-tight compartment, is filled with oil to provide lubrication to the gearing.

F. High Pressure Air System

High Pressure air passes from the air vessel past the open stop valve, to the starting valves. There are two starting valves. The small valve is opened by means of a cam on the end of a section of a geared wheel. When the torpedo is secured to the aircraft, this section of gear wheel is meshed in a rack fixed to the aircraft. When the torpedo is released, the gear wheel is revolved and the cam is forced against a lever which opens the small valve. High Pressure air then passes to the two gyros which are started and uncocked by this air blast. The large valve is opened by means of a water flap, which does not operate until the torpedo strikes the water. High Pressure air is admitted, past this valve, to the main reducer and from there to the combustion chamber.

G. Main Reducer

The main reducer is a two-stage plunger type in which high pressure air is reduced in the first stage, and further reduced in the second stage. Two small oil bottles form part of the reducer casting, each stage being lubricated by its own oil bottle. High pressure air is led into the top of the first bottle, forcing oil into the bottom of the first stage. Reduced pressure air, after it has left the first stage, forces oil out of the second bottle into the bottom of the second stage.

H. Reduced Air System

Air from the low pressure side of the main reducer is led past a combined non-return valve to the water and fuel bottles, forcing these liquids out under pressure, past a strainer and non-return valve, to the combustion chamber. A branch pipe leading from the top of the combined non-return valve admits reduced air to the depth-keeping servomotor. Another pipe from the low pressure side of the main reducer leads past a non-return valve to the top of the lubricating oil bottle, forcing the oil out to the oil distributor. A continuation of the blast high pressure air pipe to the steering gyro, is led to a disc reducer. The reduced air from this disc reducer impinges on the gyro wheel, thus maintaining the wheel speed. A separate pipe allows high pressure air to reach the disc reducer of the anti-roll gyro.

I. Combustion Chamber

The combustion chambers in torpedoes up to and including the Type 91, Modification 3, were made of 18-8 stainless steel, but changed to ordinary mild steel in all the later types.

The chamber head was originally a phosphor-bronze casting and later changed to 13% chromium steel. The chamber head is screwed and soldered to the main flask, and no difficulties have been experienced with this joint. The pipes leading from the chamber to the engine are always made of the same material as the chamber, and connected to it by a knife-edge joint with a copper gasket.

Steel used in combustion chambers must have a carbon content less than 0.15% to eliminate cracking.

The flame temperature within the chamber was never measured, but the wall temperature does not exceed 100°C during combustion. The temperature of the gases entering the engine inlet valves ranges from 500-600°C.

The main air supply enters the top of the chamber head, with 60% entering the chamber through a steel baffle plate, and 40% passing through the fuel sprayer.

Water enters the chamber through a series of small holes outside the steel baffle plate.

The fuel sprayer is similar in design to that of the Whitehead torpedo, with fuel passing thru the center of the sprayer and discharging radially from seven small holes. Above the sprayer is a rated nozzle with a 100 mesh strainer on top of it. Air enters the space between the fuel nozzle body and the fuel sprayer, and is discharged into the chamber from just behind the spray holes.

The rating figures for the combustion chamber, using water with a feed pressure of 1 kg/cm^2 (14.22 psi) for 120 seconds, are as shown in Table XIV.

Table XIV
RATING FIGURES FOR THE COMBUSTION CHAMBER

	Type 91, Modif. 3 (Improved)	Type 91, Modif. 3 (Strong)	Type 4
Water	9.9 pints	10.1 pints	10.1 pints
Fuel	3.8 pints	3.8 pints	3.8 pints
Main Air Passage	142.0 pints	143.0 pints	139.0 pints
Air For Fuel Spray	38.2 pints	38.5 pints	36.8 pints

Two ignitors are fitted in the head of the chamber, and are fired by two spring hammers released by the revolution of a cam shaft, through an adjustable ignition delay. The cam shaft is driven by the gearing on the forward engine cover.

J. Range and Speed Adjustments

There is no speed adjustment on the combustion chamber, or on the reducer, and, therefore, the torpedo had a single speed.

The range gear wheel is graduated from 0 to 5000 meters, and is driven by gearing from the engine. As the engine runs, a disc clutch revolves until a stop pin moves into a hole in the clutch. This stop pin is secured to a lever in contact with the large starting valve, and when the stop pin enters the hole in the clutch the large starting valve closes and stops the engine.

K. Engine

1. Combustion Manifold: Each outlet from the generator supplies four cylinders through pipes having 25mm (.985") inside diameter. Each pipe bifurcates twice, supplying one pair of forward and one pair of rear cylinders. The pipes are of welded construction and are bolted to the generator and heads. Much trouble has been experienced with joints due to expansion from heat. The excessive length of the piping results in undue heat losses and explains why so low a water to fuel ratio as 3.5 can be used without damage to the engine.

2. Cylinder Heads: These are phosphor-bronze castings with the thread for the union nut cut in the casting. The head is screwed onto the top of the detachable steel liner. Considerable difficulty has been experienced with pipe connections, due to the necessity for screwing the heads up to a line. A plug is screwed into the center of the head; the hole being required to obtain the timing.

The valve cap joint is made with a fibre washer.

The valve seats are detachable and are screwed into the valve chest.

Integral with the seats are the valve guides, both being of phosphor-bronze. The joint at the bottom is knife edged, and the thread makes the joint at the top. The seat is not locked in place. This arrangement is poor, because it is impossible to keep the joints tight due to the unequal expansion. There are four ports, 9mm (.355") wide and 16mm (.630") long.

3. Valves: The valve is of the standard poppet design, except that a flat seat is used instead of the normal conical one. In the head of the valve is a square recess and a threaded hole for extraction purposes.

The valve stem has four oil grooves.

The valve springs are of bronze and are totally enclosed; they are retained in place by a spring cap positioned by a square on the rear end of the stem.

The leading particulars are:

Diameter of head valve .... 40mm (1.58")
Lift .... 6mm (0.236")

4. Cylinder Liners: These are detachable, and are of steel, having a machined flange two-thirds from the bottom. They are bolted into the body, as well as screwed into the head. The main exhaust ports consist of two rows of holes.

The main details are:

Bore .... 90mm (3.55")
Thickness .... 3mm (.118")
Exhaust ports
  1st row - diameter .... 8mm (.315")
            number 20
  2nd row - diameter .... 6mm (.236")
            number 20

5. Pistons: The material of the piston is bronze. The piston is of the aircraft type with no skirt, but only thrust pads. They are fitted with a single cast iron ring. There are two gudgeon exhaust ports in the crown.

A bronze shell is inserted in the knuckle end to form the bearing surface. Principal data are as follows:

Diameter .... 89.5mm (3.526")
Clearance .... .5mm (.0197")
Exhaust ports
  Width .... 4mm (.158")
  Length .... 35mm (1.38")
Piston Ring
  Width .... 8mm (.315")
  Thickness .... 2.5mm (.10")

6. Connecting Rod: This is of H-section steel, having ports in the knuckle end to suit those in the piston. The foot of the rod is unlined and has oil grooves and holes.

Length .... 46mm (1.81")
Width .... 21mm (0.83")

7. Crankshaft: The steel crankshaft has double-throw cranks at 180° with no intermediate bearing, and is made in two parts with the crank-cheek squares on the central web. These are locked in position by grub screws. The crank webs are recessed to form the retaining rings, and the cams are formed on the balance weights of the external webs.

The crankshaft is mounted on ball bearings at each end, and has a three splined drive for the propeller shaft. The two crank pin bushings are of bronze.

The main dimensions are.

Forward bearing **journals** .... 45mm (1.77")
Diameter .... 21.5mm (0.85")
Length ....
Crank pins
Diameter .... 35mm (1.379")
Crank pin bushing .... 35.2mm (1.386")
Internal diameter .... 41.5mm (1.64")
External diameter ....
After bearing journal .... 55mm (2.17")
Diameter .... 25mm (0.99")
Length ....

8. Engine Casing: This stell casting, eight-sided, of 3.5mm thickness, is only machined to give joint faces. The cylinder liners slide in and are secured by nuts on the inside. Tappet lever brackets are screwed and sweated to it. Front and back covers are bolted to its flanged ends.

9. Front Cover: The front cover is a bronze casting bolted to the engine casing by 16 bolts, a fibre washer being used to make the joint. At its center is the forward bearing race. An extension from the main shaft passes through it to drive the water pump, oil distributor and upright shaft.

10. Rear Cover: This is of steel, and flanged to mount the engine in the afterbody. It is bolted to the engine casing in a manner similar to the front cover. It has the housing for the after crankshaft ball race, which is retained by a ring nut.

11. Engine Cooling: The external surface of the engine is cooled by sea water circulating through the engine room. The internal cooling is carried out by a water pump of the double shutter type. The delivery is through a non-return valve, **discharging** via a passage around the casting, through four outlets into the crankcase.

12. Engine Lubrication: Oil is supplied at reduced pressure to the two point oil distributor. One connection feeds oil to the eight valve stems, and the other feeds oil down through the center of the crankshaft to the two large end bearings. The lubrication of the ball bearings, pistons and knuckle ends is by splash.

13. Engine Timing: To time the engine, a bronze timing cover, graduated in degrees, is fitted in place of the front cover. A dummy spindle with a pointer is inserted in the forward journal.

L. Depth Mechanism

The depth gear is fitted in a separate removable watertight compartment in the buoyancy chamber. The gear consists of a hydrostatic valve and pendulum weight, and functions in a similar manner to depth gears in U.S. torpedoes. It also makes use of an air piston servomotor, similar to the U.S. type, which is connected by a rod to the two horizontal rudders.

An adjustable controlling gear is fitted to the servomotor, which locks the rudders until the engine starts. It is driven by gearing from the engine and can be adjusted to lock the rudders in position for different distances. The usual procedure was to lock the rudders in the "up" position for the first ten meters of water travel and free movement for the remainder of the run.

M. Gyros

Two separate air-blast, air-sustained type gyros were used in each aircraft torpedo. One gyro controlled the steering and the other controlled the anti-roll stabilizers.

In all Type 91 torpedoes the stabilizer gyro was considered as part of the torpedo, and it had no special type number. It was just called the stabilizer gyro and was different from the steering gyro. In the Type 4 torpedo, however, both gyros were the same type in order to simplify the manufacture and adjustment of the torpedo.

Table IV lists the type gyro used with each type of aircraft torpedo.

The following lists all types and modifications of gyros with the date they appeared and the principal changes made over the preceding type.

1. Type 91 Modification 1 (1943)
   a. Strength of the supporting frame was increased over that of Type 91.
2. Type 91 (Strong) (1944)
   a. Strength of the horizontal bearings was increased by changing the radius of the pivots from .0118 inches to .0197 inches.
   b. Diameter of the bottom vertical bearing was increased.
3. Type 4 (April 1945)
   a. Horizontal pivot bearings were replaced with ball bearings for increased strength.
   b. Different method of mounting to the torpedo was adopted.
   c. Design was simplified for mass production.
   d. This type used for both anti-roll stabilizers and steering control in the Type 4 torpedo.

N. Propellers

The propellers are made of either SK or Vo steel, and have a mean pitch of one meter. There is a straight line relationship between blade pitch and the distance along the radius. A section across the middle of the blade shows the driving surface as a straight line and the forward surface as a segment of a circle.

To prevent propeller damage when the torpedo enters the water, a ratchet-clutch method of free wheeling was adopted on the Type 91. (See Figure 2) This method was satisfactory for launching speeds up to 350 knots. At higher launching speeds, however, the clutch would not disengage due to inertia of the parts from the rapid deceleration of the torpedo.

An improved method of free-wheeling was adopted for the Type 4 torpedo. (See Figures 3 and 4) Centrifugal force of the engine shaft causes small bails to fly out and engage in a ratchet on the propeller shaft during normal running. When the RPM of the propeller shaft exceeds that of the engine shaft, the ratchet merely slides over the bails and depresses them, allowing the propellers to spin faster during the initial water travel. This design was highly regarded by the Japanese.

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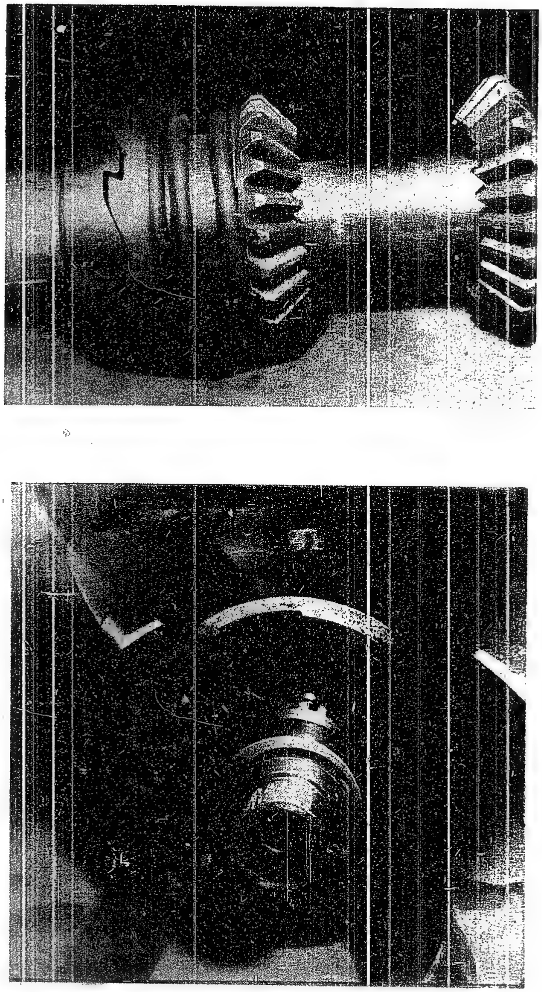

Figure 3

FREE-WHEELING PROPELLER ARRANGEMENT IN TYPE 4 AIRCRAFT TORPEDO

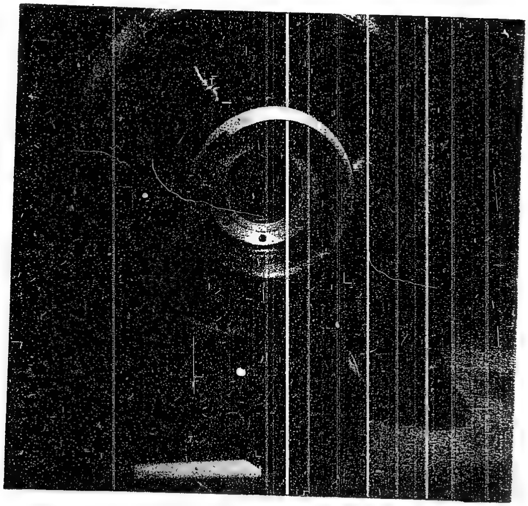

Figure 4

PARTS OF FREE-WHEELING PROPELLER SYSTEM USED IN TYPE 4 AIRCRAFT TORPEDO

O. Anti-Roll Stabilizers

With the exception of Type 91, Modification 1, all Japanese aircraft torpedoes are fitted with small, gyro-controlled anti-roll flippers. This method was adopted in 1940 on the Type 91 Modification 2 torpedo and has been a permanent feature in all the later designs of aircraft torpedoes.

Before 1940, it was necessary to lower the torpedo's center of gravity as much as possible to minimize rolling. This resulted in partial filling of the warheads with explosive charge in order to concentrate the weight below the axis of the torpedo. The introduction of anti-roll flippers, however, made complete filling of warheads possible and gave the torpedo greater destructive capacity.

The torpedo is kept from rolling during air travel with the aid of wooden frames attached to the anti-roll flippers (see Figure 7). If rolling occurs, the horizontal rudders, which have "up rudder", act as steering rudders and cause the torpedo to "hook" sharply when it enters the water. The use of roll-stablizers eliminated the "hook" and gave the torpedo excellent launching characteristics.

The Japanese claim that the use of roll-stabilizers was one of the most important features in the aircraft torpedo.

P. Air Stabilization

Japanese aircraft torpedoes are stabilized during air travel by means of wooden frames attached to the tail and to the anti-roll flippers on the sides of the afterbody. These frames break off when the torpedo enters the water.

Two types of aerial tail frames were used:

1. Box-Type Tail Frame (See Figure 5): This type was similar to the wooden stabilizers used on U.S. aircraft torpedoes. It was very large and could not be used when the torpedo was carried in the bomb bay of aircraft. For this reason, and also because of the scarcity of large sheets of plywood, the Japanese planned to use only the X-Type tail frame in the future. The box-type frame, however, gave better performance and was used occassionally on torpedoes which were slung under the fuselage of a plane.

The frame was tilted diagonally and slid over the tail fins then righted and slid back until the fins fitted into the grooves on the frame. Air pressure held the frame firmly against the fins during air travel.

2. X-Type Tail Frame (See Figure 6): This type was slightly less effective but cheaper and easier to produce. It was held in place by small wooden blocks which were bolted on after the frame was placed over the tail fins. The main advantage was in its adaptability to all types of torpedo planes.

There were also two sizes of wooden frames for the anti-roll flippers. (See Figure 7) They were wing-shaped and consisted of two half sections bolted together around the flippers. The larger size was used originally, but a smaller type was finally adopted because of the restricted openings in bomb bays.

Figures 8 and 9 are charts for determining the entrance angles and velocities of aircraft torpedoes with variable launching conditions.

Figure 10 is a graph of pitching moment in air versus angle of incidence for various types of Japanese aircraft torpedoes.

Q. Warheads

1. General: All warheads for aircraft torpedoes were filled with Type 97 explosive, which was 60% TNT and 40% Hexyl.

In 1944 the Japanese started using the Type 3 "Kite" hydroplane warhead on aircraft torpedoes as a substitute for an influence-firing exploder. Briefly, it is a remote control method for obtaining detonation under a ship's hull by towing a small hydroplane above and slightly abaft the warhead. As the torpedo passes under a ship the hydroplane strikes the hull and breaks away thereby releasing the tow line tension and firing the exploder. All details, with illustrations of th "Kite" head, are given in Part VI, Chapter II of U.S. Navy Mine Disposal Handbook dated 1 November 1944 and published by the Mine Disposal School, U.S. Navy, Washington, D.C.

In 1945 the Type 4 shaped charge warhead appeared on aircraft torpedoes. The following summary describes the warhead and the preliminary experiments made during its development.

2. Japanese "V" - Warhead (Shaped Charge): In an effort to obtain greater penetrating effects against multilayer underwater protection systems, the Japanese developed a warhead using the principle called "Neuman's Effect".

The forward end of the bursting charge has a conical cavity which is lined with a funnel-shaped, carbon-steel piece having a tensile strength of 71,000 psi. (See Figure 12 for the details of construction). When the charge is detonated by an ordinary inertial type exploder, the

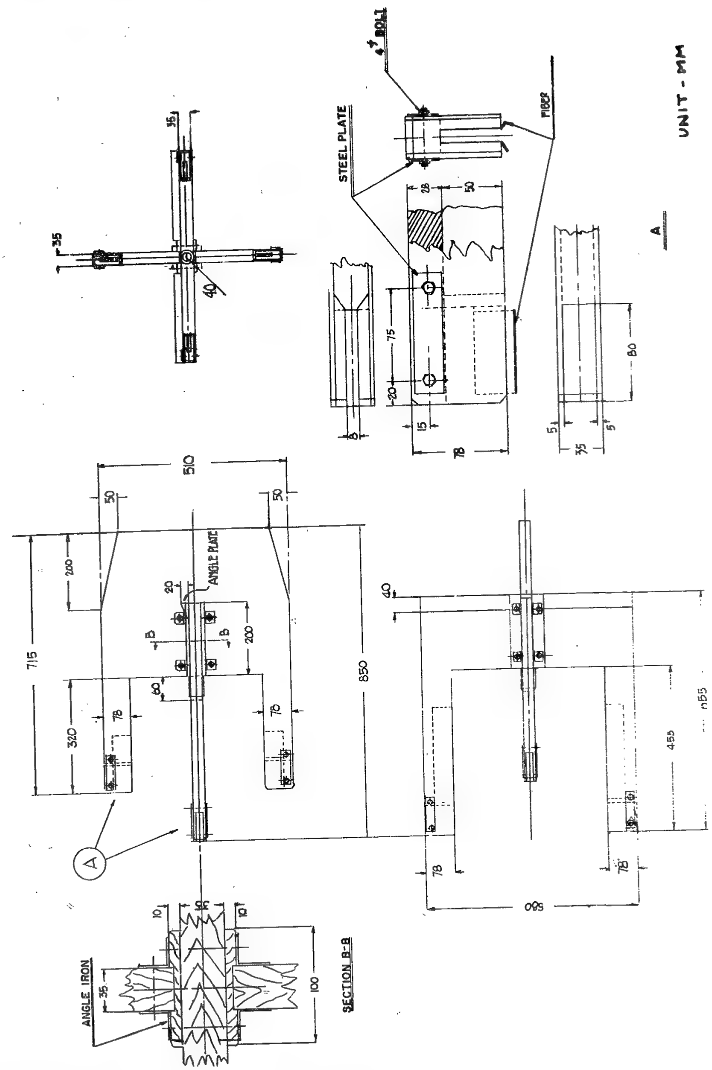

Figure 5
AERIAL TAIL FRAME (BOX-TYPE)

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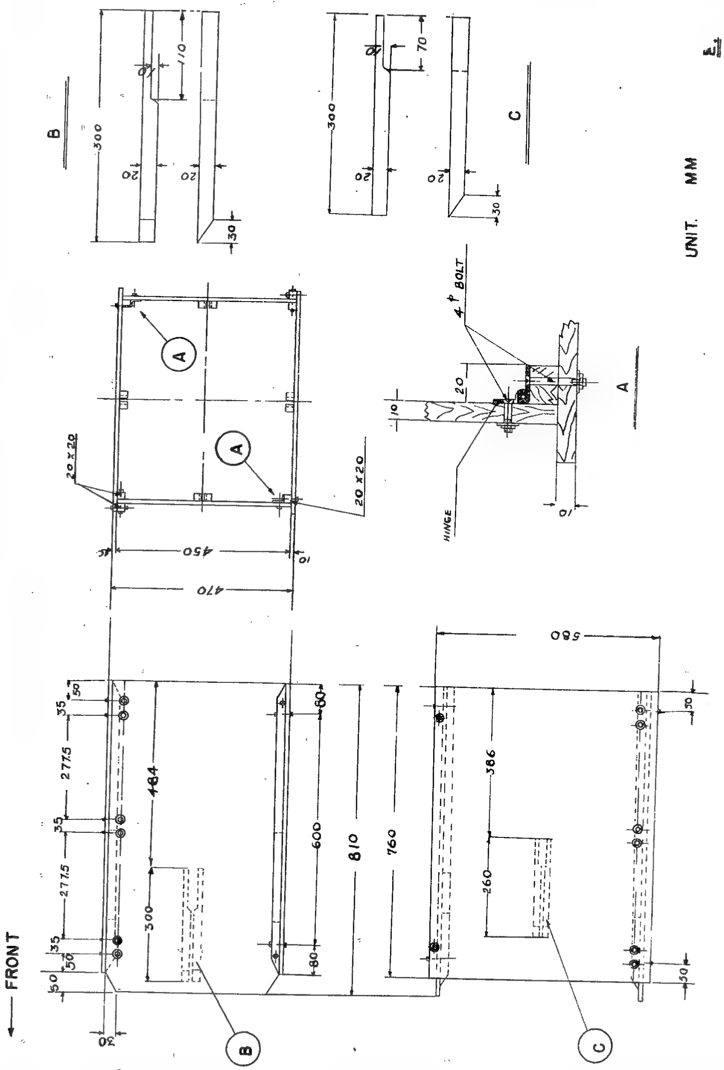

Figure 6
AERIAL TAIL FRAME (X-TYPE)

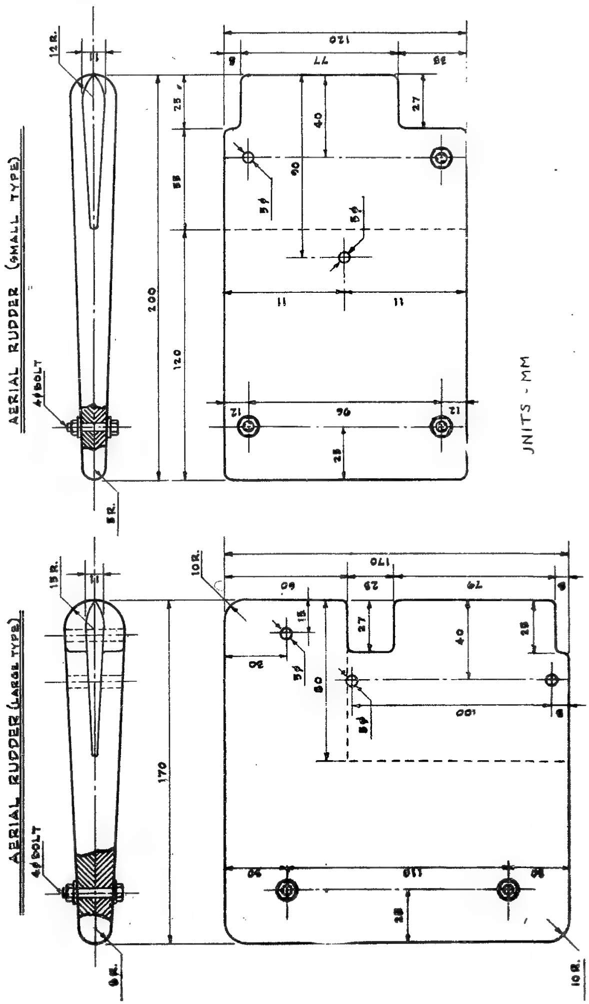

Figure 7
AERIAL RUDDER (LARGE AND SMALL TYPES)

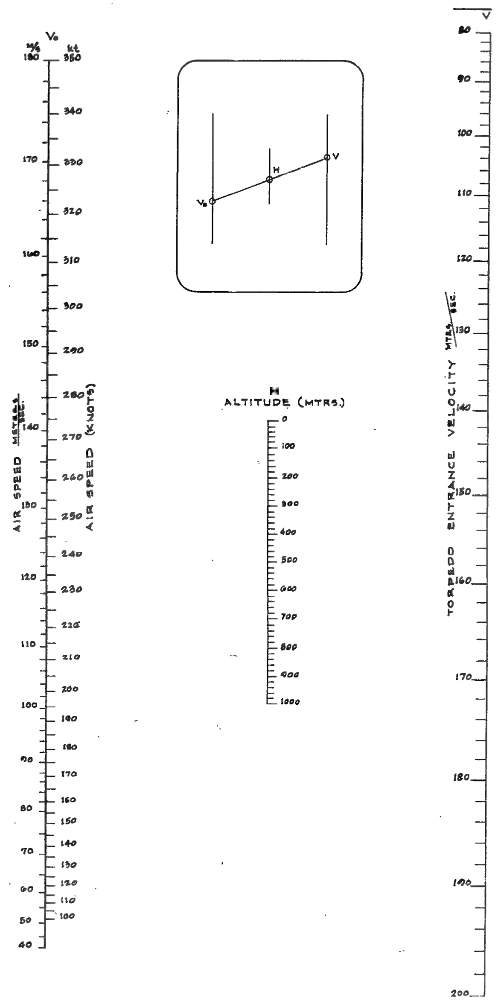

Figure 8

ENTRANCE VELOCITY CHART FOR JAPANESE AIRCRAFT TORPEDO

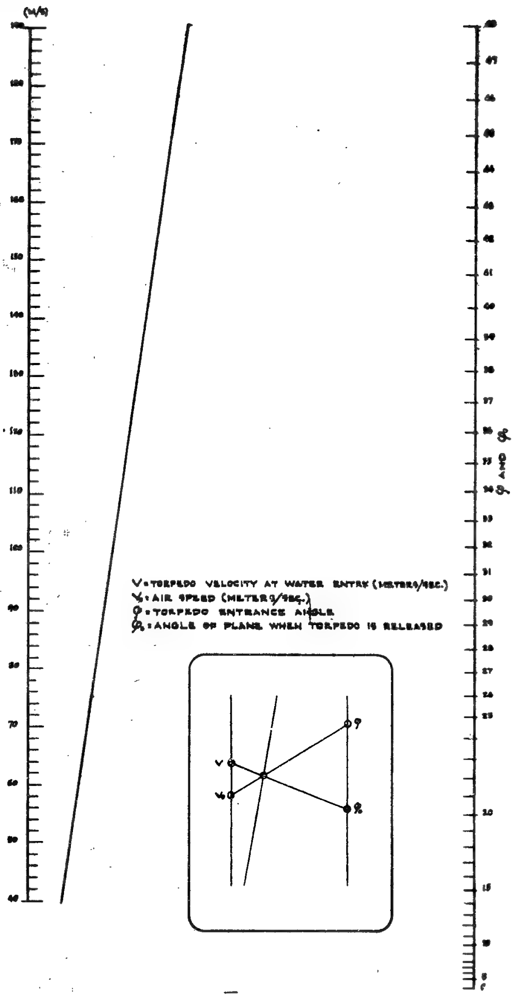

Figure 9

ENTRANCE ANGLE AND VELOCITY CHART
FOR JAPANESE AIRCRAFT TORPEDOES

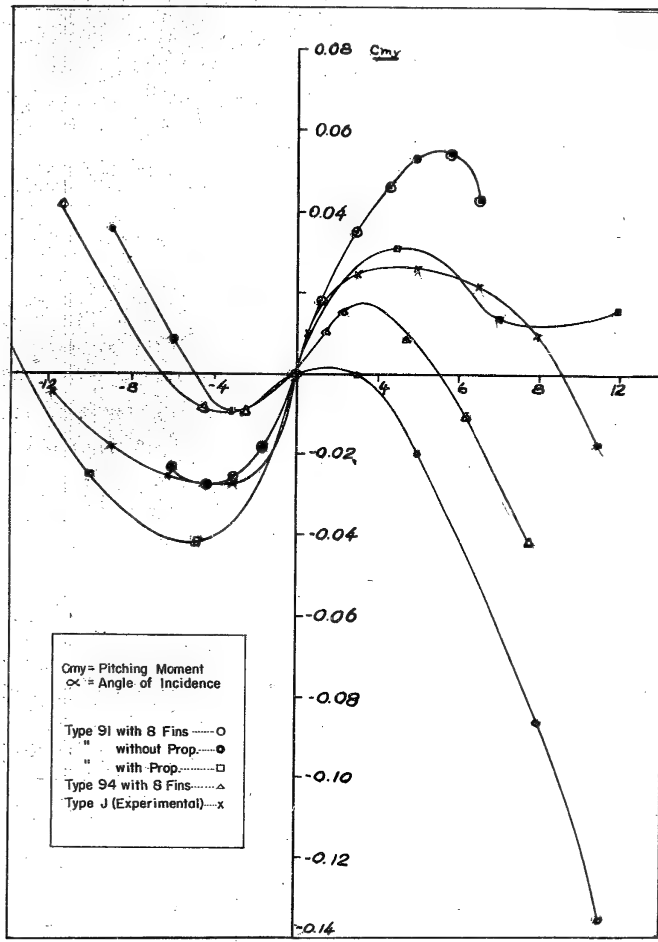

Figure 10

GRAPH OF PITCHING MOMENT IN AIR
VS ANGLE OF INCIDENCE FOR VARIOUS TORPEDOES

funnel-shaped piece is collapsed into a solid conical block by the enormous pressure and propelled forward at an extremely high velocity of about 5000 meters/sec (16,400 ft/sec).

Experiments were made with 1/10 scale models at the Technical Research Institute in TOKYO and with 1/5 and 1/3 scale models in YOKOSUKA. Full size model experiments were conducted at KURE. All tests were made in water against models of multi-layer hulls having water and air spaces.

From the results of experiments, it was found that when the line of impact was normal to the ship's hull, the projectile had the greatest effect. The penetrating power, however, varied with the angle of impact according to the "sine" rule.

Tests were conducted using full size warheads against model hulls similar to COLORADO class battleship hulls. (See NavTechJap Report "Characteristics of Japanese Naval Vessels, Article 9 - Underwater Protection", Index No. S-01-9.) These warheads actually penetrated all compartments of a model hull having the approximate dimensions shown in Figure 11.

The "V"-head was adopted for service in 1944 on the Type 93 and Type 95 torpedoes, and was designated as the Type 6 warhead.

It was first used on aircraft torpedoes in March or April 1945 and was designated as the Type 4 warhead. Commander K. FUKUBA of the First Naval Technical Arsenal near YOKOSUKA, said that three "V"-heads were used on aircraft torpedoes at this time in actual combat. He believed that a U.S. destroyer and a light cruiser were damaged near KYUSHU. This was the only information obtainable on actual service use.

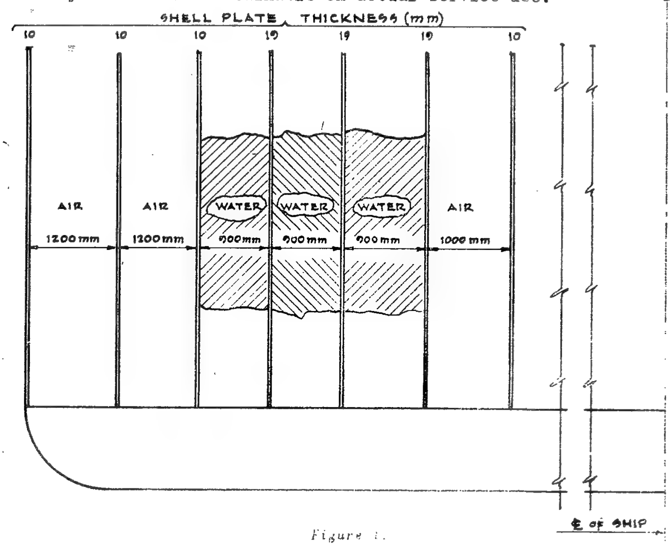

Figure 1.

HULL DIAGRAM FOR V-WARHEAD TESTS

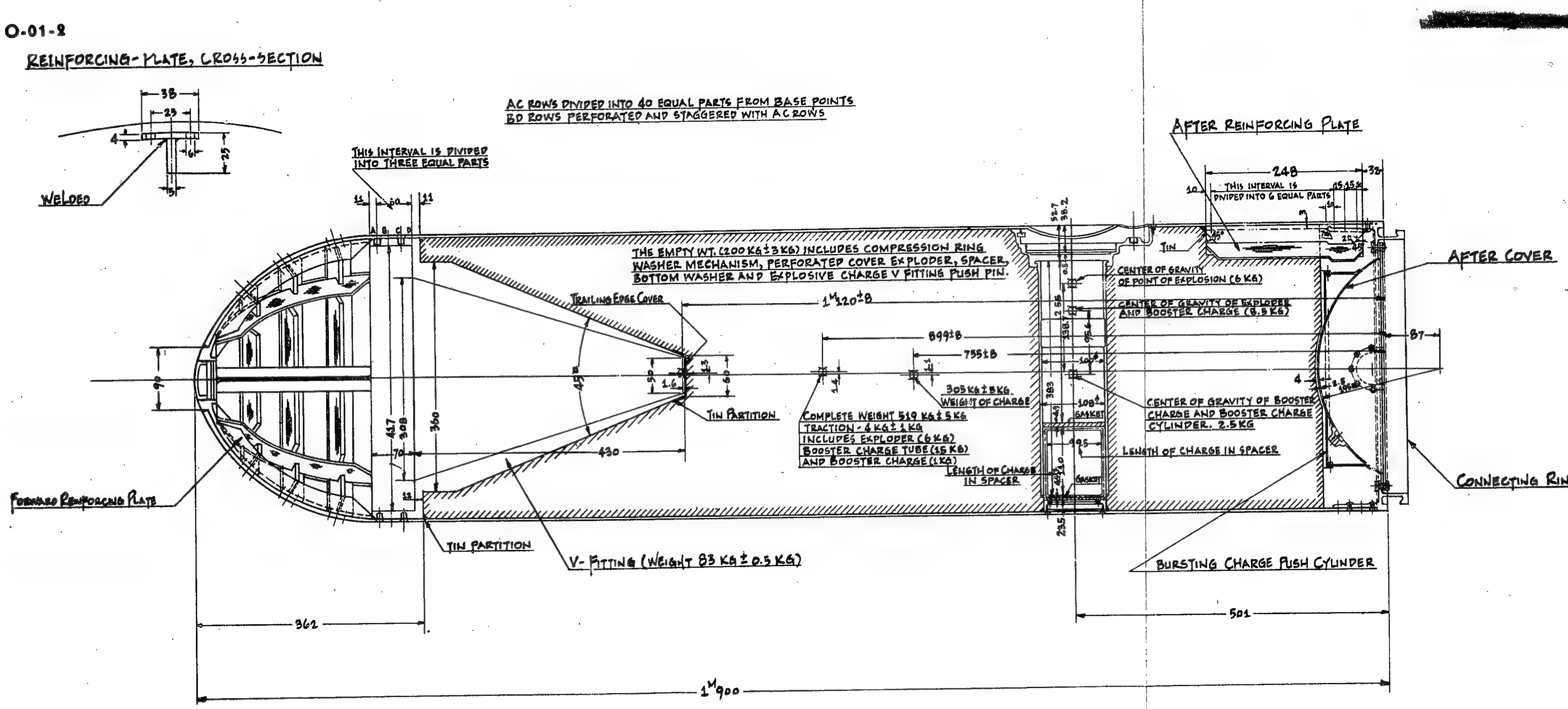

Figure 12

DETAILED DRAWING OF TYPE 4 WARHEAD

OVERALL DIAGRAM

R. Exploders

The Type 90, Model 2; Type 90, Model 2 (strong), and the Type 4 were the only exploders used in aircraft torpedoes.

1. Type 90, Model 2 Exploder

a. General

(1) Bail, impact type, inertia-firing exploder, fitted transversely in a pocket on top center-line of warhead.
(2) Used in aircraft torpedoes.

b. Description

(1) External: The exploder is cylindrical in shape, 13.7 inches long, 4.0 inches body diameter, 5.2 inches diameter at top flange and 6.7 inches diameter at top cover. A three-bladed impeller protrudes from the top center of the cover and carries a spring-loaded bail arched over it. Fitted to the bail is a small lug which prevents a rotation of the impeller until the bail is depressed.

(2) Internal: The exploder consists of two main parts as follows:

(a) An upper section 7.8 inches long, which houses:

(i) Arming assembly composed of:

(aa) The impeller.
(bb) A reduction gear system.

(ii) Firing assembly composed of:

(aa) An inertia trigger, which is a brass cup with an elliptical base, shaped to insure displacement when subjected to shock. The trigger is locked before launching by a cylindrical mask, which is lifted when the bail is depressed by water travel.
(bb) A spring loaded firing spring assembly, centrally located in the lower part of the section and held in the cocked position by two lock detents.

(b) A lower section, housing the detonator, gaine and booster. The gaine is held centrally in the booster, and the booster is aligned with the upper section by a machined ring.

(3) Method of mounting: The exploder is secured in the warhead pocket by a series of bayonet joints between lugs on the exploder flange and corresponding lugs on the retaining ring, which is screwed into the exploder pocket. Abaft the pocket is a gear articulating with a rack on the retaining ring. Rotation of this gear within the "Limit-stops" locks or releases the pistol in the pocket.

c. Operation

(1) Water travel depresses the bail, lifting the mask from the inertia trigger. As the impeller rotates it drives the

[redacted]

reduction gear system, performing the following arming functions:

(a) The firing pin is screwed down to the firing position.
(b) The inertia trigger is unlocked.

(2) Impact displaces the inertia trigger, aligning an escape channel for the two locking detents, which are forced outward by the firing pin as it moves down into the detonator.

2. Type 90 Model 2 (strong)

This was a mass produced and cheapened Type 90.

3. Type 4

This was a further cheapened and simplified Type 90.

S. Exercise Heads

Standard water-blowing type exercise heads were used on all aircraft torpedoes. The heads could be set to blow whenever the torpedo velocity dropped below a certain speed. This method was used in exercise heads for all Japanese torpedoes, and is discussed in detail in NavTechJap Report, "Japanese Torpedoes and Tubes, Article 1 - Ship and Kaiten Torpedoes", Index No. 0-01-1.

Part III

JAPANESE EXPERIMENTAL AIRCRAFT TORPEDOES

A. Type 94 Aircraft Torpedo

This was an oxygen torpedo very similar to the Type 95. Its development was stopped in 1935 after about two years of experimentation. It was designed by Technical Rear Admiral S. NARUSE of the First Naval Technical Arsenal, but was very complicated and the handling of oxygen was troublesome. The only advantage in the use of oxygen was for long range, and the Japanese decided that long range was not needed in aircraft torpedoes. Therefore, all production and research were abandoned.

Only about 100-120 were made at YOKOSUKA and NAGASAKI Arsenals before production was stopped.

The general particulars for the Type 94 torpedo are as follows:

Diameter	
Total length	17.7 in
Total weight	208 in
Displacement	1870 lbs
Negative buoyancy	1210 lbs
Warhead	660 lbs
	Same as Type 91, Modif. 1
Weight of Explosive (Type 97)	330 lbs
Exploder	Type 90 (inertia type)
Speed	45 knots
Range	2200 yards
Air vessel	Shorter than Type 91 A.V.
Water	Used a sea water pump
Fuel	Kerosene fed by pressure of the sea water pump
Reducer	Same as Type 91
Generator	Wet heater type
Engine	8-cylinder, radial engine same as Type 91
Max. horsepower	
Air to fuel ratio	250
Starting sequence	2.5-2.8
	Same as in Type 93 torpedo
Anti-roll stabilizers	None

B. Type M Torpedo

This is a 23 inch aircraft torpedo, and was under development from 1942 to 1944. It was planned to use the torpedo with a new, large type of seaplane but the design of the plane was never completed.

The only operational difference from the Type 91 aircraft torpedo, was the use of a semi-internal combustion engine. In an effort to increase the efficiency, experiments were made using a second fuel bottle and injecting a small amount of fuel directly into the cylinders by means of a distributor (See Figures 14 and 15). The distributor rotor was geared to the engine shaft, and the injection was timed as shown in Figure 13. This second fuel was ignited by the hot gases from the combustion chamber, which had already been admitted to the cylinders. The result was an increase in pressure as shown in Figure 13.

No cooling water was used in the torpedo.

Only three Type M torpedoes were made at the First Naval Technical Arsenal, but development did not get beyond the bench test stage.

The main troubles experienced were:

1. Poor ignition of the second fuel.
2. Low air efficiency of 180 B.H.P. per lb of air per second instead of the expected 250-275.
3. Gas leakage through the valves.
4. Difficulties with distributor design.

Because of these difficulties and the halting of the seaplane design, all research on the Type M torpedo was abandoned in 1944.

The principle dimensions can be seen in Figure 17 and Table XV.

C. QR Spriralling Torpedo

This torpedo was developed for use against submarines. The idea was suggested by Rear Admiral S. NARUSE of the First Naval Air Technical Arsenal near YOKOSUKA, and its development was under the supervision of Engineer K. NOMA.

The experimental type letters Q and R were assigned during its development.

1. Construction (See Figure 18): It was a Type 91, Modification 2 aircraft torpedo, with further modifications to make it run in circles and descend at the same time.

The following changes were made to obtain the desired results:

a. Remove the cover from depth gear.
b. Blank off the safety valve in the buoyancy chamber.
c. Run an air pipe from low pressure side of the reducer into the buoyancy chamber and install a 1.0mm diameter nozzle in the chamber end of the pipe.
d. Set the reducer pressure at 11 kg/cm^2 (157 psi).
e. Remove the steering and stabilizer gyro and blank off both of the gyro air leads.
f. Install a 1.0mm diameter nozzle in the steering air lead so that air is discharged into the afterbody.
g. Install a safety valve in the afterbody shell to keep the internal air pressure and the sea pressure equalized. The valve is set to operate at a pressure of about 5 psi.
h. Increase the width of the vertical rudders to 1.40 inches.

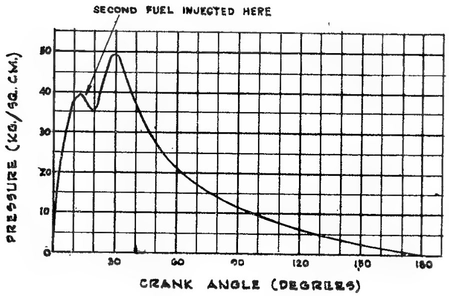

Figure 13

ENGINE DIAGRAM FOR TYPE M TORPEDO

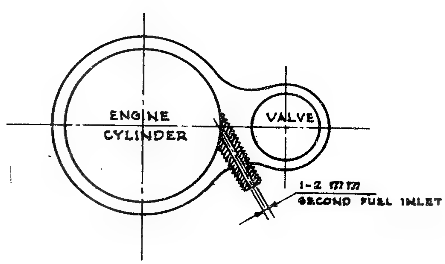

Figure 14

SECOND FUEL INJECTION SYSTEM
FOR TYPE M TORPEDO

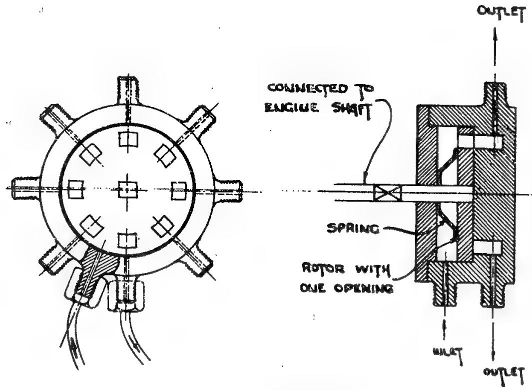

Figure 15
SECOND FUEL DISTRIBUTOR
FOR TYPE M TORPEDO

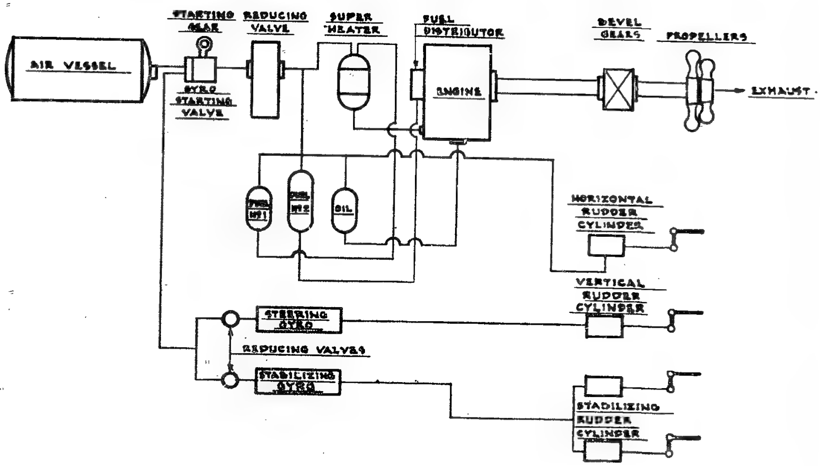

Figure 16
PIPE ARRANGEMENT FOR TYPE M TORPEDO

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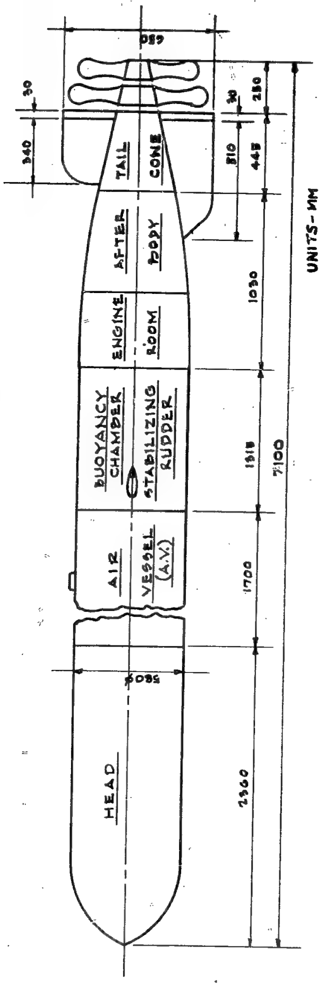

Figure 17
DIMENSIONAL DIAGRAM OF AIRCRAFT TORPEDO TYPE M

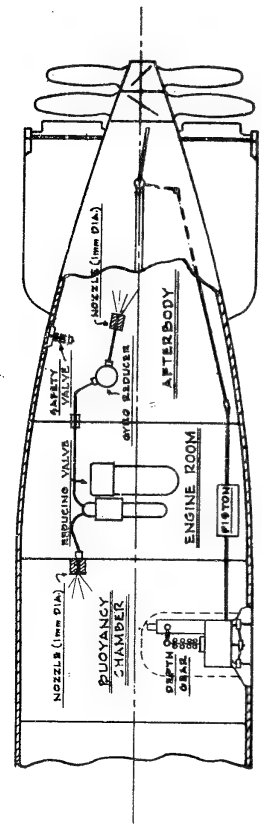

Figure 18
SCHEMATIC DIAGRAM FOR THE QR SPIRALLING TORPEDO

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Table XV
PRINCIPAL ITEMS OF TORPEDO
Mark M

Warhead	B.C.	kg	750
Warhead	Length	mm	2360
Warhead	Weight	kg	1100
Total length		mm	7100
Total width		mm	2070
C.G. from tail end		mm	4050
Displacement		kg	1556
Trim		mm	-190
Negative buoyancy		kg	514
C.B. from tail end		mm	3860
Speed		knots	50
Range		m	2500
Maximum allowable launching speed		knots	300
Air Vessel	Air pressure	kg/cm^2	220
Air Vessel	Volume	lit	380
Air Vessel	Weight of air	kg	96
Air Vessel	Thickness	mm	10
Air Vessel	Length	mm	1700
Air Vessel	Factor of safety		1.76
Air Vessel	Material		V9,SK,V

Various Liquid Bottles	Fuel Bottle No. 1	Volume	lit	10
Various Liquid Bottles	Fuel Bottle No. 1	Thickness	mm	3.5
Various Liquid Bottles	Fuel Bottle No. 2	Volume	lit	16
Various Liquid Bottles	Fuel Bottle No. 2	Thickness	mm	3.5
Various Liquid Bottles	Oil bottle	Volume	lit	5.5
Various Liquid Bottles	Oil bottle	Thickness	mm	3
Engine		Weight	kg	120
Engine		Number of cylinders		8
Engine		Area of cylinder	cm^2	122.8
Engine		Bore diameter	mm	125
Engine		Stroke	mm	105
Engine		Indicator diagram efficiency	%	80
Engine		Mechanical efficiency	%	85
Engine		Air efficiency	BHP per kg of air	550
Engine		Maximum brake horsepower	hp	470

i. Fix the vertical rudders at an angle of 10-15 degrees to the right.

2. Operation: When the torpedo is launched, air from the reducer is bled through the nozzle into the buoyancy chamber. Air pressure gradually builds up on top of the uncovered diaphragm in the depth gear at a slightly greater rate than that of the sea pressure. The diaphragm is depressed causing slight down rudder and the torpedo starts to descend in a spiral path.

3. Characteristics: Due to the low reducer pressure, the torpedo's speed was reduced to about 26 knots, but the range was increased to approximately 4000 yards. The diameter of the spiral was about 300 yards with an initial pitch of 20 yards, increasing to about 35 yards at maximum depth. The maximum depth for the torpedo was about 320 feet.

4. Manufacture and Use: At the beginning of 1945, ten QR torpedoes were made at the First Naval Air Technical Arsenal and about forty at the Nagasaki Arsenal. Scarcity of materials halted production.

The Japanese considered the QR torpedo a success as far as technical aspects were concerned, but not enough were made for effective operational use.

Some torpedoes were issued to the service but no information was obtainable on the results of service use.

D. Model 4 Aerial Torpedo:

This is a bomb-torpedo having no propulsion. Its movement through the water depends only on the momentum imparted to it when launched from an airplane.

1. Construction: The torpedo consists of the head and the afterbody. The afterbody has two anti-roll stabilizers similar to those used on the Type 91 aircraft torpedoes, as well as vertical and horizontal fins. The roll stabilizers and vertical rudders are controlled by two separate gyros and servomotors. The air supply comes from a small flask inside the afterbody. The horizontal fin is set at zero degrees, but a small steel triangular box is attached to the top of the fin so that it forms an angle of 30 degrees with the horizontal, and has a height of 100mm (3.49 in) at the trailing edge.

2. Principal Dimensions:

Diameter	17.7 in
Total length	116.7 in
Length of head	61.5 in
Length of afterbody	55.2 in
Total weight	1100 lbs
Weight of explosive (Type 98)	550 lbs
Pull around	22 lbs
Thickness of head shell	0.157 in
Thickness of afterbody shell	0.130 in
Thickness of vertical and horizontal fins	0.157 in

3. Detonator: Two detonators are used in this torpedo. A bomb-type fuze is set in the nose, which functions in the case of a direct hit but not upon entering the water. An ordinary Type 90, Model 2 inertia pistol is installed in the middle of the head.

4. Characteristics: The torpedo was developed for use against surface shipping. When launched from a plane with an air speed of 200-300 knots, an altitude of 900-1500 feet and a diving angle of 20-30 degrees, the

depth of the dive does not exceed 35 feet. Even after a water travel of 300 feet, the velocity is still more than 20 knots.

5. Progress Summary: Between February and October 1943 about forty firing tests were made, using Type 97 carrier based planes and TENZANS (JILL 11).

a. About twenty-five launchings were made under the following conditions:

Altitude .... 900-1300 feet
Air speed .... 200-280 knots
Diving angle .... 20 degrees

The results were poor. Only one-third made good runs at a depth less than thirty feet. One-third made very erratic runs and the rest went down to great depths. The following reasons were given for the poor performance:

(1) Poor stability due to small L/D ratio of 6.6.
(2) Inadequate strength of fins.
(3) Variations in launching conditions.

b. About fifteen level launchings were made at altitudes of 300-500 feet and air speeds of 150-240 knots. Results were comparatively good, with two-thirds making satisfactory runs. The rest ran deep and erratic.

As a result of these tests the Japanese did not consider the torpedo practical enough for service use.

E. Model 6 Anti-Submarine Circling Torpedo

With the exception of a steel nose section to withstand the force of impact, and two small wing braces, the entire torpedo was constructed of wood. It consists of three sections; the head, fuselage, and tail section. Wooden wings run the whole length of the fuselage with a dihedral of 20 degrees. The fuselage was made of laminated wooden sheets and had a total thickness of 15mm (0.59 inches). The wings and rudder were glued to the fuselage and tail section. The rudder was fixed at an angle of eight degrees causing the torpedo to make circles of about 260 feet in diameter. It had no propulsion, and a specific weight of 1.4 which made the torpedo sink in a spiral path having a pitch of about 200 feet.

To prevent the eight degree rudder displacement from affecting the air flight, a wooden fairing was fitted over the rudder. It was held in place by a small aluminum pin which sheared when the torpedo entered the water.

It was planned to use a magnetic proximity fuze, but the development never reached that stage.

1. Principal Dimensions

Total length .... 116.7 in
Diameter .... 11.8 in
Total weight .... 595 lbs
Wing spread .... 30 in
Weight of explosive (Type 98) .... 220 lbs
Wing area .... 10 ft^2
Wing load .... 580 lbs
Thickness of vertical and horizontal fins .... 1.2 in

[redacted]

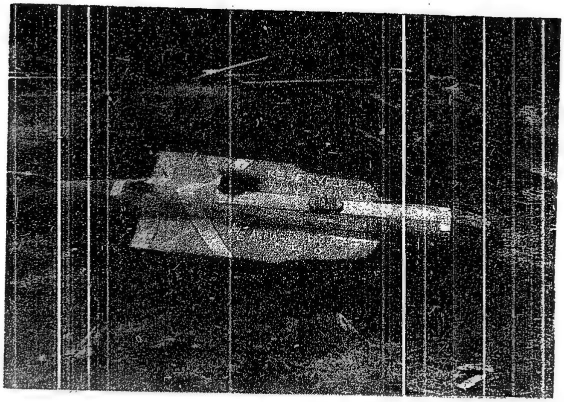

Figure 19
MODEL 6 ANTI-SUBMARINE AERIAL TORPEDO BOMB

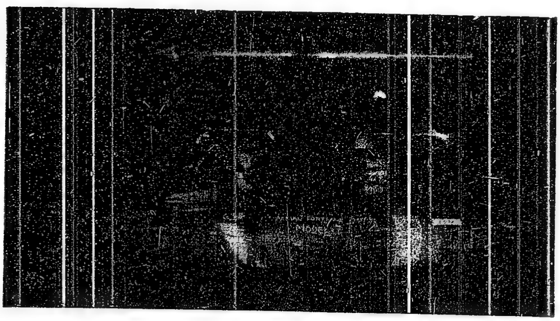

Figure 20
MODEL 7 AERIAL TORPEDO BOMB
WITH WOODEN WINGS REMOVED

RESTRICTED

[redacted]

2. Test Results In September 1944, about 40 launchings were made from aircraft with air speeds of about 145 knots and a diving angle of 15-20 degrees. It was found that gliding characteristics were poor and rolling occured.

Tests were also made on water entry characteristics of the torpedo. On impact the wings were severely damaged and sometimes torn off. In cases where the wings stayed on, the torpedo porpoised severely.

No further experiments were made after 1944.

F. Model 7 Aerial Torpedo

The Model 7 was an anti-submarine circling torpedo similar to the Model 6, but having a steel fuselage and tail section. Wooden wings ran the whole length of the torpedo, from the head joint to the tail fins, with a dihedral angle of 15 degrees. The air gliding speed was about 250 knots at an approximate angle of 20 degrees. The vertical rudder was set at an angle of six degrees and a 30 degree angle board 20mm high fixed on top of the horizontal fin.

1. Principal Dimensions

Total length ....
Diameter .... 116.7 in
Wing spread .... 11.8 in
Total weight .... 31.0 in
Thickness of fuselage shell .... 1100 lbs
Explosive charge .... 0.475 in
Wing area .... 485 lbs
Wing load .... 17 ft^2
Thickness of vertical and horizontal fins .... 690 lbs
.... 0.98 in

2. Test Results: Underwater travel tests were not made, but it was expected to describe a spiral path similar to the Model 6 aerial torpedo bomb and with approximately the same velocity.

In January 1945 eleven gliding tests were made using an air speed of 220 knots, altitude of 1000 feet and a diving angle of 15 degrees. The lateral stability was poor and excessive rolling occurred in all cases.

It was definitely decided that anti-roll stabilizers should be installed, but no further tests were made with the Model 7 aerial torpedo.

G. Model 8 Aerial Torpedo

After many efforts to obtain a successful bomb torpedo, the Model 8 finally achieved some degree of success just before the end of the war.

It was similar to the Model 4 in design and operation, and differed from it only in the following points:

The L/D ratio was increased from 6.6 to 11 with a resulting increase in stability.
The thickness of the head shell was increased from 0.157 inches to 0.473 inches to improve its penetrating ability.
The vertical and horizontal tail fins were strengthened to withstand the impact of water entry.
The height of the 30 degree angle box fixed to the top of the horizontal fin was changed from 100mm (0.394 in) to 70mm (0.275 in).

[redacted]

1. <u>Principal Dimensions</u>

Diameter	
Total length	11.8 in
Length of head	130.0 in
Length of afterbody	69.3 in
Total weight	60.7 in
Weight of explosive	1100 lbs
Pull around	352 lbs
Thickness of head shell	4.4 lbs
Thickness of afterbody shell	0.473 in
Thickness of vertical and horizontal fins	0.130 in
	0.157 in

2. <u>Detonator</u>: Same as in Model 4 aerial torpedo bomb.

3. <u>Test Results</u>: In July 1945 six launching tests were made from a plane with air speeds of 200-250 knots, altitudes of 60-350 feet, and angles of 0-15 degrees.

The results were good and all torpedoes stayed within a depth of 35 feet, and had a minimum velocity of 25 knots after 230 feet of water travel. No further experiments were made before the war ended a few weeks later.

H. <u>Rocket and Jet Torpedoes</u>

In 1941 the Japanese experimented with jet-propelled aircraft torpedoes. The engine was removed from a Type 91, Modification 3 torpedo and the gases from the combustion chamber were ejected through a nozzle in the tail. Kerosene was used as fuel, and burned in the same manner as in ordinary aircraft torpedoes. This was the Type 1 torpedo and only four of them were made for experimental purposes. It had a maximum range of 320 yards with a speed of 30 knots. Difficulties were found with unsteady combustion and poor depth control. All experiments were discontinued after three months.

In 1944, efforts were made to develop a rocket torpedo using tetra-nitromethane and methyl alcohol for fuel. Laboratory tests were made on the combustion of this fuel and it was found that ordinary igniters did not develop enough heat to start combustion. Experiments were made igniting kerosene in the chamber first, and then injecting other fuels afterwards. It was designated as a KR torpedo, but all experiments were unsuccessful and were abandoned a few months later.

ENCLOSURE (A)

PRODUCTION AND COST FIGURES FOR JAPANESE AIRCRAFT TORPEDOES AND MINES

EMPLOYMENT IN ORDNANCE PLANTS

	Year	Size of Plant	Number of Plants	Total Workers	Total Hours Worked	Total Wage Bill
Aircraft Torpedo	1941	Over 1000 workers	1 (Nagasaki)	1800	5,400,000	5,400,000
		100-1000 workers	1 (Yokosuka)	400	1,200,000	1,200,000
		Under 100 workers				
	1942	Over 1000 workers	1 (Nagasaki)	4600	13,800,000	13,800,000
		100-1000 workers	1 (Yokosuka)	400	1,200,000	1,200,000
		Under 100 workers				
	1943	Over 1000 workers	2 (Nagasaki & Hikari)	6900	20,700,000	20,700,000
		100-1000 workers	4 (Y, Kure, Kawatana, & Mizuru)	2150	6,450,000	6,450,000
		Under 100 workers				
	1944	Over 1000 workers	3 (Nagasaki, Kawatana, & Hikari)	25000	75,000,000	75,000,000
		100-1000 workers				
	1945	Over 1000 workers	2 (Nagasaki & Kawatana)	18200	54,600,000	54,600,000
Aircraft Mine Type 3, No. I	1943	100-1000 workers	2	1400	2,350,000	2,350,000
	1944	100-1000 workers	3	2640	7,920,000	7,920,000
	1945	100-1000 workers	2	1600	800,000	800,000
Aircraft Mine Type 3, No. II	1943	100-1000 workers	1	560	420,000	420,000
	1944	100-1000 workers	5	860	2,580,000	2,580,000
	1945	100-1000 workers	4	560	560,000	560,000
Aircraft Mine Type 3, No. III	1944	100-1000 workers	2	700	1,225,000	1,225,000

REQUISITE TIME FROM RAW MATERIALS TO COMPLETE ORDNANCE

A.T. Type 91 .... 5000 hours

A.M. Type 3, No. I .... 1200 hours

A.M. Type 3, No. II .... 500 hours

A.M. Type 3, No. III .... 2500 hours

[redacted]

ENCLOSURE (A), continued

ORDNANCE STOCKS IN ARSENALS AND FACTORIES
CONTROLLED BY NAVY
(Yen Value)

	Category	March 1941	March 1942	March 1943	March 1944	March 1945
Aircraft Torpedoes	Finished Products	3,525,000	1,620,000	1,500,000	2,696,500	2,082,500
	Finished Components	750,000	1,522,500	2,625,000	11,418,000	7,962,500
	Work in Progress	1,250,000	220,950	3,285,900	11,649,750	9,555,000
	Raw Material	525,000	975,000	2,450,000	7,035,000	4,655,000
	TOTAL	6,050.000	4,338,450	9,860,900	32,797,250	24,255,000
Aircraft Mine Type 3, No I	Finished Products				1,137,500	2,145,000
	Finished Components				2,762,500	1,950,000
	Work in Progress				3,315,000	2,340,000
	Raw Material				1,657,500	1,170,000
	TOTAL				8,872,500	7,605,000
Aircraft Mine Type 3, No II	Finished Products				360,000	868,000
	Finished Components				720,000	1,008,000
	Work in Progress				864,000	1,209,600
	Raw Material				432,000	604,800
	TOTAL				2,376,000	3,690.400

ENCLOSURE (A), continued

EFFECT OF AIR ATTACKS
(AIRCRAFT TORPEDO AND AIRCRAFT MINE)
Data for 1945

Name of Plants	Date of Air Attack	Capacity (%)		Output		Physical Damage (%)	Inventory Loss (Yen)	Capacity after Recovery	Terms for Recovery
		Before	After	Before	After				
Nagasaki Arsenal	9 Aug. 1945	100	0	120	0	almost 100	Unknown	Nothing	Nonrecovery
Isomura Products Co. Ltd.	24 May 1945	100	0	40	0	100	Unknown	Nothing	Dispersion
Ozaki Mfg. Co. Ltd.	10 Mar. 1945	100	0	80	0	100	Unknown	Nothing	Production stop
Saito Centrifugal Machine Co. Ltd.	14 May 1945	100	0	50	0	100	Unknown	Nothing	Production stop
Tokyo Electric Co. Ltd.	25 May 1945	100	80	30	20	20	Unknown	80	
Morita Pump Mfg. Co.	1 June 1945	100	0	40	0	100	Unknown	Nothing	Production stop

[redacted]

ENCLOSURE (A), continued

PLANS FOR DISPERSION
Annual Data 1944 - 1945

	Plan of Dispersion				Execution of Dispersion				
	Before	After				1944		1945	
	Capacity	Division	Capacity		Division	Capacity		Capacity	
Aircraft Torpedo	450	Overground	200	450	Overground	450	20	450	140
	Kawadena 200	Underground	130		Underground		70		130
	Nagasaki 250	Mainland	0		Mainland				
		Maintenance	120		Maintenance		360		180
Aircraft Mine	640	Overground	215	640	Overground	330		640	60
		Underground	50		Underground				10
		Mainland	0		Mainland				
		Maintenance	375		Maintenance		330		570

ORDNANCE PRODUCTION PLANS
Annual Data 1931 - 1940

Items	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940
A.T. Type 91, Mod I	10	50	100	150	200	250	300	300	300	450
A.T. Type 94, Mod I								5	35	25
A.T. Type 94, Mod II								70	130	

ORDNANCE PRODUCTION PLANS
Monthly Data 1941 - 1945

	Item	Date of Plan	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total Year
1941	A.T. Type 91, Mod II	Dec. 1940	5	5	5	5	5	5	5	5	5	5	5	5	60
	A.T. Type 91, Mod II	Feb. 1941	40	40	40	40	40	40	40	40					320
	A.T. Type 91, Mod III	Aug. 1941									50	70	100	100	320
1942	A.T. Type 91, Mod III	Dec. 1941	5	5	5	5	5	5	5	5	5	5	5	5	60
	A.T. Type 91, Mod III	Feb. 1942	100	100	100	100	100	100	100	100	100	100	100	100	1200
1943	A.T. Type 91, Mod III	Feb. 1942	100	100	100	110	115	120	190	185	215	215	245	235	1930
	A.T. Type 91, Mod III	Dec. 1942	5	7	8	10	10	10	10	15	15	20	20	20	150
	A.M. Type 3, No. I	June 1943					20	30	100	150	250	250	250	250	1300
	A.M. Type 3, No. II	Nov. 1943										100	200		300
1944	A.T. Type 91, Mod II	Dec. 1943	280	320	350	390	440	430	440	420	490	475	445	465	4940
	A.T. Type 4	Dec. 1943			10	10	10	20	30	50	60	100	130	140	560
	A.M. Type 3, No. I	Dec. 1943	175	175	175	325	345	365	395	405	425	425	425	425	4060
	A.M. Type 3, No. II	Jan. 1944	325	325	325	325	355	385	405	455	525	525	525	525	4970
	A.M. Type 3, No. III	Jan. 1944	50	50	50	50	50	50							300
1945	A.T. Type 91, Mod III	Dec. 1944	150	150	150	150	150	150	150	150	150	150	150	150	1800
	A.T. Type 4	Dec. 1944	250	250	250	250	300	300	300	300	350	350	400	400	3700
	A.M. Type 3, No. I	Dec. 1944	300	300											600
	A.M. Type 3, No. II	Dec. 1944	360	360	360	360	360	360							2160

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ENCLOSURE (A), continued

ORDNANCE PRODUCTION
Annual Data 1931 - 1945
(Yen Value*)

Item	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945
A.T. Type 91, Mod I	7	53	702	150	193	237	308	312	280	450					
A.T. Type 91, Mod II											237				
A.T. Type 91, Mod III											473	1200	1800	3565	297
A.T. Type 4														328	552
A.T. Type 94, Mod I								5	32	21					
A.T. Type 94, Mod II								62	138						
A.M. Type 3, No 1													530	2500	283
A.M. Type 3, No 2														1990	430
A.M. Type 3, No 3														250	

ORDNANCE PRODUCTION
Annual Data 1931 - 1945
(Number of Units)

Item	1931	1932	1933	1934	1935	1936	1936	1938	1939	1940	1941	1942	1943	1944	1945
A.T. Type 91, Mod I	105	785	153	225	2895	3555	4620	4680	4200	6750					
A.T. Type 91, Mod II											3695				
A.T. Type 91, Mod III											7110	18195	31950	88735	8039
A.T. Type 4														3431	7170
A.T. Type 94, Mod I								175	1120	735					
A.T. Type 94, Mod II								1860	4140						
A.M. Type 3, No I													3575	16250	18395
A.M. Type 3, No II													540	2502	1204
A.M. Type 3, No III														20875	

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ENCLOSURE (A), continued

ORDNANCE PRODUCTION
Monthly Data 1941 - 1945
(Yen Value*)

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total Year
1941	A.T. Type 91 Mod. II	360	420	595	460	610	480	270	500					3695
	A.T. Type 91 Mod. III							145	350	1120	1960	990	2545	7110
1942	A.T. Type 91 Mod. III	985	1275	2675	1285	1615	1685	1305	2525	1875	1390	815	1825	18195
1943	A.T. Type 91 Mod. III	1365	1296	1215	1552	1691	2060	2222	3153	2709	2956	3752	6679	31950
	A.M. Type 3 No. I						162.5	325	325	325	975	995	1789.5	4975
	A.M. Type 3 No. II											180	360	540
1944	A.T. Type 91 Mod. III	6568	9284	7629	8319	8809	9375	9098	9157	8141	6871	4193	3298	88729
	A.T. Type 4									662	1490	1291	1987	4089
	A.M. Type 3 No. I	1137.5	325	1462.5	1139.5	1039	1170	1235	1300	1332.5	1830	2145	2145	16250
	A.M. Type 3 No. II				36	99	135	180	225	360	405	477	558	2492
	A.M. Type 3 No. III	417.5			417.5	417.46	417.46	417.5						2087.42
1945	A.T. Type 91 Mod. III	3418	1418	1452	2100									8074
	A.T. Type 4	1656	2765	2748	1980									11094
	A.M. Type 3 No. I	1300	539.5											1839.5
	A.M. Type 3 No. II	476	196	252	280									1204

*Units 1000 yen.

ENCLOSURE (A), continued

ORDNANCE PRODUCTION
Monthly Data 1941 - 1945
(Number of Units)

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total Year
1941	A.T. Type 91 Mod. II	22	27	38	29	40	31	17	33					237
	A.T. Type 91 Mod. III							9	22	72	128	64	168	473
1942	A.T. Type 91 Mod. III	60	84	177	85	107	112	86	101	124	91	53	120	1200
1943	A.T. Type 91 Mod. III	89	84	79	98	103	125	129	184	135	158	270	340	1800
	A.M. Type 3 No. I						25	50	50	50	100	100	175	550
1944	A.T. Type 91 Mod. III	293	315	321	337	311	302	390	394	330	261	204	149	3565
	A.T. Type 4									40	90	78	120	328
	A.M. Type 3 No. I	175	50	225	175	160	180	190	200	205	280	330	330	2500
	A.M. Type 3 No. II				20	50	75	100	140	200	225	265	310	1390
	A.M. Type 3 No. III	50			50	50	50	50						250
1945	A.T. Type 91 Mod. III	144	48	45	60									297
	A.T. Type 4	100	167	165	120									552
	A.M. Type 3 No. I	200	83											283
	A.M. Type 3 No. II	170	70	90	100									430

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ENCLOSURE (A), continued

ORDNANCE PRODUCTION BY INDIVIDUAL PLANTS
(Yen Value*)

		Year	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total Year
Nagasaki Arsenal	A.T. Type 91 Mod II	1941	240	360	495	360	570	420	210	430					3135
	A.T. Type 91 Mod III	1941							105	270	960	1800	870	2445	6450
	A.T. Type 91 Mod III	1942	825	1215	2575	1245	1575	1665	1245	1485	1825	1290	735	1225	17425
	A.T. Type 91 Mod III	1943	1260	1170	1110	1215	1200	1500	1455	2265	1185	1500	2670	3420	19950
	A.T. Type 91 Mod III	1944	3161	3565	3407	3723	3161	3249	3548	3633	3161	2002	2933	1879	37442
	A.T. Type 4	1944									662	1490	1291	1987	4087
	A.T. Type 91 Mod III	1945	1598	263	87										1948
	A.T. Type 4	1945	1656	2765	2948	1980									11094
Yokosuka Arsenal	A.T. Type 91 Mod II	1941	120	60	100	100	40	60	60	20					560
	A.T. Type 91 Mod III	1941							40	80	160	160	120	100	660
	A.T. Type 91 Mod III	1942	100	60	80	40	40	20	60	40	60	100	80	100	780
	A.T. Type 91 Mod III	1943	105	126	105	147	168	210	147	168	210	336	315	441	2478
	A.T. Type 91 Mod III	1944	546												546
Kure Arsenal	A.T. Type 91 Mod III	1943				190	228	190	100	285	209	380	513	418	2603
Hikari Arsenal	A.T. Type 91 Mod III	1943						160	160	160	320	320	1024	1440	3584
	A.T. Type 91 Mod III	1944	1356	2144	2400	2496	2848	2624	3520	3264	2830	2944			26976
Isomura Products	A.M. Type 3 No. II	1944				18	36	36	54	90	126	126	144	162	792
	A.M. Type 3 No. II	1945	112												112
Ozaki Mfg. Co.	A.M. Type 3 No. II	1944				18	27	45	54	54	90	108	108	144	648

*Units 1000 yen.

ORDNANCE PRODUCTION BY INDIVIDUAL PLANTS (Cont.)
(Yen Value*)

		Year	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total Year
Niigata Yoki	A.M. Type 3 No. II	1944					18	18	36	54	54	54	90	108	432
	A.M. Type 3 No. II	1945	140	140	196	224									700
Toko Electric Co.	A.M. Type 3 No. II	1944										27	45	54	126
	A.M. Type 3 No. II	1945	34	56	56	56									252
Ishikawa Mfg. Co.	A.M. Type 3 No. I	1944				325	650	975	975	975	975	975	975	975	7800
	A.M. Type 3 No. I	1945	650	214.5											864.5
Morita Pump Co.	A.M. Type 3 No. I	1944					64	195	195	195	195	260	260	260	1625
21st Aerial Arsenal	A.M. Type 3 No. I	1944							65	130	162.5	260	260	260	1137.5
Osaka Machinery Co.	A.M. Type 3 No. I	1943										325	325	650	1300
	A.M. Type 3 No. I	1944	1137.5	325	1462.5	812.5	325	0	0	0	0	325	650	650	5687.5
	A.M. Type 3 No. I	1945	650	325											975
Saito Centrifugal Machinery Co.	A.M. Type 3 No. III	1944					18	36	36	54	90	90	90	90	504
	A.M. Type 3 No. III	1945	140												140
Aichi Dokei	A.M. Type 3 No. III	1944				417.5	208.75	208.75	417.5						1252.5
Maizuru Arsenal	A.T. Type 91 Mod III	1943							260	0	260	0	0	260	780
	A.M. Type 3 No. I	1943						162.5	325	325	325	650	650	1137.5	3675
	A.M. Type 3 No. II	1943											180	360	540
	A.M. Type 3 No. III	1944	417.5	0	0	0	208.71	208.71							834.92

ORDNANCE PRODUCTION BY INDIVIDUAL PLANTS (Cont.)
(Number of Units)

		Year	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total Year
Nagasaki Arsenal	A.T. Type 91 Mod II	1941	16	24	33	24	38	28	14	32					209
	A.T. Type 91 Mod III	1941							7	18	64	120	58	163	430
	A.T. Type 91 Mod III	1942	55	81	173	83	105	111	83	99	121	86	49	115	1161
	A.T. Type 91 Mod III	1943	84	78	74	81	80	100	97	151	79	100	178	228	1330
	A.T. Type 91 Mod III	1944	180	203	194	212	180	185	202	208	180	114	167	107	2132
	A.T. Type 4	1944									40	90	78	120	328
	A.T. Type 91 Mod II	1945	91	15	5										111
	A.T. Type 4	1945	100	167	166	120									553
Yokosuka Arsenal	A.T. Type 91 Mod II	1941	6	3	5	5	2	3	3						28
	A.T. Type 91 Mod II	1941							2	4	8	3	6	5	33
	A.T. Type 91 Mod II	1942	5	3	4	2	2	1	3	2	3	5	4	5	39
	A.T. Type 91 Mod II	1943	5	6	5	7	8	10	7	8	10	16	15	21	118
	A.T. Type 91 Mod II	1944	26												26
Kawadana Arsenal	A.T. Type 91 Mod III	1943					3	0	0	5	15	12	18	20	73
	A.T. Type 91 Mod III	1944	29	45	52	60	80	100	58	64	60	55	36	40	679
	A.T. Type 91 Mod III	1945	52	33	39	60									174
Kure Arsenal	A.T. Type 91 Mod III	1943				10	12	10	10	15	11	20	27	22	137
Hikari Arsenal	A.T. Type 91 Mod III	1943						5	5	5	10	10	32	45	112
	A.T. Type 91 Mod III	1944	58	67	75	78	89	82	110	102	90	92			843
Maizuru Arsenal	A.T. Type 91 Mod III	1943							10	0	10	0	0	10	30
	A.M. Type 3 No. I	1943						25	50	50	50	50	50	75	350
	A.M. Type 3 No. II	1943											100	200	300
	A.M. Type 3 No. III	1944	50	0	0	0	25	25							100

RESTRICTED

ENCLOSURE (A), continued

ORDNANCE PRODUCTION BY INDIVIDUAL PLANTS (Cont.)
(Number of Units)

		Year	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total Year
Osaka Machinery Co.	A.M. Type 3 No. I	1943										50	50	100	200
	A.M. Type 3 No. I	1944	175	50	225	125	50					50	100	100	875
	A.M. Type 3 No. I	1945	100	50											150
21st Aerial Arsenal	A.M. Type 3 No. I	1944							10	20	25	40	40	40	175
Ishikawa Mfg. Co.	A.M. Type 3 No. I	1944				50	100	150	150	150	150	150	150	150	1200
	A.M. Type 3 No. I	1945	100	33											133
Morita Pump Co.	A.M. Type 3 No. I	1944					10	30	30	30	30	40	40	40	250
Isomura Products	A.M. Type 3 No. II	1944				10	20	20	30	50	70	70	80	90	440
	A.M. Type 3 No. II	1945	40												40
Ozaki Mfg. Co.	A.M. Type 3 No. II	1944				10	15	25	30	30	50	60	60	80	360
Saito Centrifugal Machinery Co.	A.M. Type 3 No. II	1944					10	20	20	30	50	50	50	50	280
	A.M. Type 3 No. II	1945	50												50
<u>Aichi Dokei</u>	A.M. Type 3 No. III	1944				50	25	25	50						150
<u>Niigata Yoki</u>	A.M. Type 3 No. II	1944					10	10	20	30	20	30	50	60	240
	A.M. Type 3 No. II	1945	50	50	70	80									250
Toko Electric Co.	A.M. Type 3 No. II	1944										15	25	30	70
	A.M. Type 3 No. II	1945	30	20	20	20									90